Conservation manual

For Earth Architecture Heritage in the pre-Saharan valleys of Morocco

2005

CERKAS / UNESCO World Heritage Centre / CRATerre-EAG

Contacts

CERKAS

Center for Conservation and Rehabilitation of the architectural Heritage of the Atlas and sub-Atlas zones
Tel/fax: +212 (0)44 88 30 47
Kasbah Taourirt
BP 253 Ouarzazate, Morocco

Ministry of Culture, Kingdom of Morocco

1, rue Gandhi,
Rabat
Maroc
Tel. +212 (0)37 20 94 06/29 Fax. +212 (0)37 70 84 17

CRATerre-EAG

International Centre for Earth Construction - Ecole d'architecture de Grenoble
B.P. 2636
38036 Grenoble Cedex 2, France
Tel: +33 (0)4 76 40 14 39 Fax: +33 (0)4 76 22 72 56

UNESCO

World Heritage Centre / Arab States Unit
7, Place Fontenoy
75352 Paris 07 SP, France
Tel: +33 (0)1 45 68 15 77

UNESCO Regional Bureau

35, Avenue du 16 novembre
BP 1777, Agdal
Rabat, Maroc
Tel. +212 (0)37 67 03 72 / 74

Ministerio de cultura de España

The ministry of Culture of Spain has funded the preparation of this manual

Authors

Mohamed Boussalh, ethnologist, director, CERKAS
Mustapha Jlok, ethnologist, conservator, IRCAM
Hubert Guillaud, architect, CRATerre-EAG
Sébastien Moriset, architect, CRATerre-EAG

Illustrations

Photographs
Large photograph on cover: reconstruction of a rammed earth wall during the restoration of the communal granary of Tazlaft
Photographic credits: All photographs by Mohammed Barjali, photographer, CERKAS
Except for the following photographs, by Sébastien Moriset, CRATerre : cover br, 11bl, 13tl, 13br, 15, 16, 17, 19, 21, 22, 24bl, 24 tr, 30, 32bl, 33tl, 35, 44, 59bl, 59bc, 59br, 61, 62, 64, 68
(tl: top left, tr : top right, bl : bottom left, bc : bottom center, br, bottom right)

Drawings
All drawings by Bouchra Fadli, architect, and Hamid Aghazzaf, main technician, CERKAS
Except for the following, by CRATerre : 23, 33, 36r, 37l, 41c, 41r, 43, 44, 45, 46, 63br

This document was translated into English by Leticia Delboy, CRATerre-EAG

This conservation manual was produced in 2004 by
CERKAS and CRATerre-EAG, with the financial help of
UNESCO World Heritage Centre.
Original document written in French.
A translated Arabic version is available.

We thank all the persons who have participated in the proofreading of this manual, and who have offered us their precious remarks.

Contents

Foreword

This manual was created with the intention of reducing the malpractices affecting the earth architecture heritage in Southern Morocco, in order to preserve what remains of its exceptional nature. The architectures existing in these valleys, such as the World Heritage Site of Ait Benhaddou, are unique and fragile. The factors of degradation are many, and the buildings are strongly subject to being altered; every replacement of a door, every damaged decoration, every reconstruction using concrete blocks represents a step towards the disappearance of the richness of this heritage. The conservation of the splendours of these ancient structures does not come into contradiction with the modernization of life and the improvement of the living conditions of those who reside in them. However, certain ethical rules must be complied with to avoid the destruction of the cultural values existing within these walls. Rules of good conduct, as regards to conservation, are proposed in this manual.

This manual also offers indications on maintenance and conservation techniques best adapted to these earth architectures. If modern materials damage the visual integrity of the site, they are also often poorly adapted to the earth structures and can prove to be highly destructive. Constructive traditions preserved by the *mâalems* have long proven to be efficient, and long lasting.

This manual is addressed to all those wishing to undertake construction works on ancient cities, which represent Morocco's remarkable architectural heritage. Those concerned include:

- Institutions (town councils, rural municipalities, local authorities, delegation of Tourism, delegation of Culture, delegation of Habitat, direction of Equipment and Public Works, Architecture and Town Planning division, National Water Board, National Power Authority)
- The owners of the structures (residents)
- Investors (private investors or sponsors)
- Professionals of the construction industry (architects, enterprises, craftsmen)

The purpose of this manual is:
- To reduce the speed of degradation of the value of this heritage, by informing the decision makers, the proprietors and the investors on the laws and codes governing its conservation,
- To help those in charge, the owners, and those willing to invest, to make right decisions as regards to the conservation, the transformation and the general improvement of the sites,
- To promote State services, by informing the readers of their existence, while specifying their role and the assistance they can provide,
- To improve the quality of the interventions on the sites, by providing technical recommendations for the implementation of maintenance, conservation and restoration works.

1. Introduction

While earth is a commonly used construction material in all continents, few civilizations have had the audacity to build structures comparable to those on the pre-Saharan valleys of Morocco. This monumental earth architecture is the result of an exceptional know-how, and the perfectly mastered use of high quality materials. It constitutes a priceless heritage, a living memory reflecting the capacities and know-how of the people of the area, their social organization, and their everyday life. However, the necessary conditions for its conservation are not met anymore, and the problem of conserving and restoring the earth architectures of Morocco is becoming more and more serious. In all areas located beyond the Atlas, the great *Ksour* complexes and the medinas, as well as the rural settlements, are confronted with innumerable problems.

The cultural heritage made up primarily of stately residences (*Tighermt-s* in Berber, *Kasbahs* in Arabic) and of Community villages (*igherm-s* or *Ksour*) undergoes the consequences of a social evolution that is not easily controllable, and which puts in danger the cultural values of many generations, while threatening numerous architectural masterpieces. Indeed, these human settlements that were once structured according to established Community rules are undergoing a disjuncture process, sometimes causing the rupture of the bonds that originally existed between Man and his social and natural environments.

These often irreversible mutations affect the traditional social structures and result in the emergence of new practices. Thus, modern materials have little by little replaced the use of adobe and rammed earth, gradually changing the landscapes of these beautiful areas of Morocco. In view of the magnitude of this phenomenon, the Moroccan authorities have become aware of the urgency to slow down this evolution, and to protect the sites and monuments of this great cultural heritage.

In spite of the efforts made to preserve the essence of this architecture, the situation remains critical. Earth architectures, strongly degraded, are in a state of utter abandonment. The financial means available for conservation are insufficient, and many problems arise:

- Total desertion
- Demographic explosion
- Disjuncture of traditional socio-economic structures
- Weakness of the local economy
- Absence of basic infrastructures
- Intensive rural emigration
- Complexities regarding land ownership

Reflections concerning the protection of the earth architectural heritage should aim at dealing with current problems which can jeopardize the future, namely:

- The installation of the necessary infrastructures
- The adaptation of existing buildings to contemporary needs
- The development of housing for a growing population

To maintain the population in an environment that does not fulfil the requirements of today's life, without undertaking concrete actions, puts the perpetuity of the earth architecture heritage at risk. The time has come to encourage an "integrated conservation" of vernacular architectures into the regional development strategies, by working out synergies of actions between the Ministries of Culture, Habitat, Public Works, Education, Tourism…

The integration of the architectural heritage in a sustainable development approach is a decisive as well as fundamental step. A global reflection should be carried out in the fields of town planning and the protection of earth architectures. Why not work out an experimental project through the collaboration of many institutions for the construction of earth dwellings in the city of Ouarzazate? This initiative could also be applied in other areas where raw earth is still used.

A partnership policy with the services of the Ministry of Tourism should result in projects of conversion of existing earth architectures into lodgings, inns, etc., or in training seminars for guides. Local collectivities should be involved at a decision-making level. A policy of maintenance supported by the local collectivities would prove to be more effective in terms of financial management. It would have to be made sure that the various interventions suggested address real problems and that the recommended solutions are in accordance with the needs of the population. An accurate definition of the programming criteria for a cultural, tourist and social strategy, in close connection with the institutions concerned, should be a main area of concern for all stakeholders.

2. Factors of degradation

2.1. Introduction

In order to understand the processes of degradation having led to the pathologies that are visible today, it is important to study the main factors of degradation. These are of two types, natural and human.

- **Natural** factors of degradation, such as rain, wind, or seisms, are not easily controllable and often unforeseeable.
- **Human** factors of degradation are relative to human activities that take place in or around the sites. The abandonment, the incorrect use of a site or the introduction of new materials are recognized as factors of degradation.

A factor of degradation seldom acts in an isolated way. It is always necessary to take into consideration several sources of degradation combined when evaluating the state of degradation of a site (domino effect). The human factors of degradation often generate an acceleration of the degradation process in relation to natural factors. A lack of maintenance of the drainage slopes, for example, can cause a series of destructive phenomena, starting with the erosion of the bases of walls due to the stagnation of water.

In order to understand the degradation problems affecting a building, an in-depth study of the site as a whole is required, taking into account its environmental, physical and human characteristics. The study of the site as a whole, and not only of the damaged element, is important because the causes of degradation are sometimes found far from the studied building.

2.2. Natural factors of erosion

2.2.1. Direct action of rainwater

Observation of earth architectures shows us that rainwater degrades the non-protected parts of buildings. It mainly erodes the top and the base of the walls. Erosion of vertical surfaces is also an issue, especially on the west facades, due to the action of the wind and the effects of the oceanic climate, but it takes place at a slower pace.

2.2.2 Specific erosion

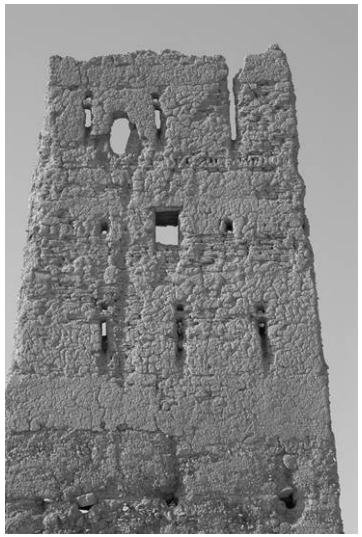
Some parts of the earth buildings are particularly prone to erosion. These weak spots correspond to the areas where the surface waters converge. Specific erosions take place, amongst other places, under the roof scuppers, around the gutters and water channels, the window frames and around the junction between the parapet walls and the flat roof. Large specific erosions can occur on the interior walls, when there is a roof leakage. Great damage can occur in a short period of time.

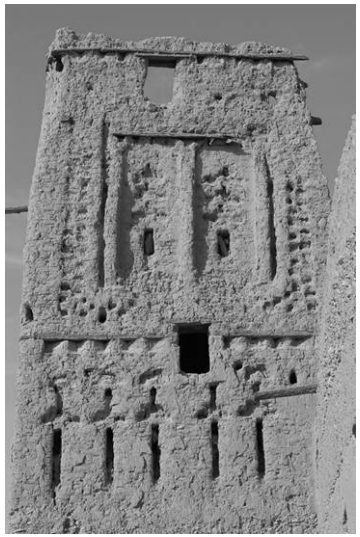
2.2.3. Water runoff

Water runoff on the ground can be more or less destructive, depending on the morphology of the terrain, the soil's absorption capacity, and the rate of the water-flow. For the *Ksours*, streets and lanes have a double function:

- A function relative to space (arteries of circulation)
- A function relative to evacuation and drainage

Due to a lack of maintenance, or following a transformation, the lanes do not function as natural drainers for rainwater anymore. Heavy rains tend to transform them into devastating torrents, which destroy the bases of the walls. The destruction process takes place at an even faster pace when the bases of the walls are not protected from water, and if the material is already weakened through the impact of capillarity.





Erosion at the top and on the vertical surfaces of walls

Sand sinking

Erosion of the roof due to water infiltration

Undercut at the base of a wall

2.2.4. Stagnations and infiltrations

The rainwaters can often get stuck on water-retention zones that have been formed following a wall collapse, the transport of matter through streaming, or the presence of elements blocking the way. Errors in the implementation of slopes can also lead to the formation of water-retention zones. Water can also stagnate inside the buildings, when leakages from the roof are left unrepaired.

Most of the stagnant water gets infiltrated into the earth structure, reducing the cohesive properties of the material.
Earth is a capillary material, which absorbs moisture and restores it by evaporation. The moisture contained in the walls can become dangerous when the infiltrations are significant, since clay, which ensures the resistance of the material, starts to lose its cohesive properties, causing the softening-up of humidified material. The earth thus weakened can be easily carried away by the wind, the rain, or the streaming waters. Even worse, moisture can lead to the structural deformation or the collapse of a building.

Waterproof coatings such as cement-based coatings can worsen the situation, since they prevent the evaporation of moisture from the walls.

2.2.5. Action of the wind

The wind is a natural factor of erosion. It can erode matter by itself, especially when it has been humidified by rain or by capillary action before hand. In combination with the rain, the wind can cause the acceleration of an erosion process of the earth surfaces, by increasing the impact speed of raindrops, especially at the top and on the corners of walls. Loaded with dust and sand, the wind erodes matter through mechanical action. In the long run, it can cause the sand sinking of buildings. The sand accumulated at the base of the walls or at the top of the parapet walls retains moisture, which contributes to the migration of moisture into the walls, and the creation of erosion furrows at their base.

Poor drainage leads to water stagnation. Humidified structures end up collapsing (right photograph)

Lack of maintenance, improper disposal of garbage and floor paving using non-porous materials are factors that contribute to moisture-related problems.

2 .3 Human factors of degradation

Man takes part directly in the destruction of heritage, sometimes consciously, more often by ignorance. We can point out:

- The lack of maintenance or the abandonment of buildings due to succession-related problems and property-ownership complexities
- The abandonment due to a lack of comfort and to the absence of infrastructures
- Transformations and new installations (electric installations, running water, new materials, film sets)
- The development of new activities related to tourism (souvenir shops, hotels
- The improper management of waste
- The plundering of decorated elements (sculpted doors and windows)

2.3.1 Property ownership: a complex situation

Most *Ksour* are the collective property of those who reside in them. Their management is under the command of the *"jmaa",* the local collective assembly. For any intervention relative to the conservation or the restoration of a building,
a complex procedure has to be followed, involving the traditional collective assembly but also the local authorities. Conflicts often arise when dealing with the residents.
Most *Kasbahs* are private properties. This does not always simplify their property status, since the *Kasbahs* often shelter extended families, with all the complications that this entails. The heirs are numerous, their opinions are sometimes discordant, and they do not own a property title. This often leads to family feud.

2.3.2. Physical transformations

The introduction of new materials such as cement plasters and screeds, and the lack of knowledge of the properties of earth materials, has often led to trouble. The fragile balance of earth structures has often been altered, through the generation of specific, concentrated areas for moisture exchange. The introduction of the running water system has often been done in an archaic way, with an inappropriate management and disposal of the wastewater discharges.
Similarly, the electrical supply network, with its chaotic arrangement of apparent cables, its ill-assorted urban luminaries and its unsightly meters, disfigure the urban landscapes of the *Ksours* and *Kasbahs*.

Physical transformation affecting the urban landscape: cables and electric meters, urban luminaries and new materials

Architectural transformations: extensions made in concrete blocks

2.3.3. Tourism (tourist crowds)

Tourists directly damage the sites, while accessing and group visiting the fragile structures. But the consequences of these tramplings are limited, and only affect the most-visited sites. The most harmful effects of tourism are indirect. The surge of crowds of well-to-do visitors leads to the development of new activities (mechanical sports such as motorcycle squad rides) and the installation of seldom controlled commercial structures (hotels and restaurants), affecting the physical and visual integrity of the sites. The proliferation of souvenir shops, often accompanied by very large and visible signs, has also altered the appearance of the streets.

2.3.4. The film industry

The development of cinematographic activity in this area has led to the exploitation of the earth architecture heritage, and has introduced exogamic elements into the landscape, new buildings, new doors, the painting of traditionally unpainted elements… Some *Ksours* and *Kasbahs* have served as a stage for internationally known films such as *Laurence of Arabia, Jesus of Nazareth The Jewel of the Nile, Gladiator, Kingdom of Heaven,* etc. While this activity makes it possible to generate new resources for the local population, the exploitation of the sites it often poorly managed.
Consequently, the structures of the buildings, the decorations, the collective or private spaces, undergo uncontrolled modifications and transformations. It is urgent to:

- Inform the persons in charge of the cinematographic sector of the cultural values to be preserved on the sites
- Work out specific action plans to preserve the authenticity of the sites
- Organize regular inspections carried out by professionals during shootings
- Comply with UNESCO's international recommendations and with the guidelines contained in the Charter of Venice
- Involve the film industry in the restoration projects for earth architectures and in the development of the villages and *Ksours*.

Physical transformations affecting the World Heritage Site of Aït Benhaddou:

Entrance constructed for the film Laurence of Arabia in 1962, never destroyed after the shooting

Turrets built in 2000 on the enclosure wall of a hotel
located in the vicinity of the site

3. Good practices

3.1. Ethical principles of conservation

An intervention on a historic site is deemed acceptable when it does not alter its authenticity. On the pre-Saharan valleys of Morocco, authenticity relates to the shape, the function, the materials and the construction techniques employed. It is a difficult task to guarantee that the authenticity of the sites is respected and maintained, since any intervention on a site inevitably implies an alteration of the values attached to it, and the inclinations towards change are many. But the complete abandonment of a site also leads to its loss. Thus, acceptable compromises should be found, in order to reconcile conservation with the requirements of modern living.

Which are the great principles to be respected in priority?

- **Respect of architecture**: The aesthetical values of traditional architectures must be kept alive. This architecture is the first noteworthy element of the region's heritage. It has enchanted many visitors, in the past, and will attract many more as long as it remains. The conservation of this architectural value implies the respect of the traditional shapes, colors, textures, materials and techniques. Any intervention or modification should be as discreet as possible.

- **Reversibility**: All interventions should be reversible. This requires the use of materials and techniques which make it possible to return to the original situation in case a significant ethical or technical problem arises.

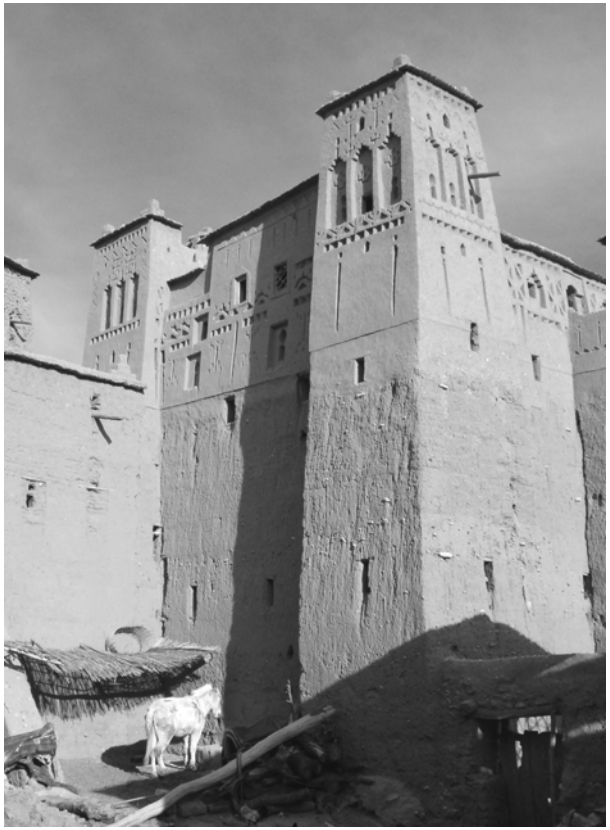
What does the law state?

All *Ksours* and *Kasbahs* of the valley of Drâa are listed as World Heritage sites since 1943. This implies that precise administrative procedures should be followed with every intervention on the heritage. Any modification, even partial, cannot be carried out without the accord of the administration.

« L'immeuble ou le meuble inscrit ne peut être dénaturé ou détruit, restauré ou modifié sans qu'avis n'en été donné à l'administration par le ou les propriétaires, six mois avant la date prévue pour le commencement des travaux »
(loi n° 22-80 chapitre II - Article 6)
Translation: *"The listed immovable or movable heritage cannot be denatured or destroyed, restored or modified, without the consent of the Administration, which should be informed by the owner or owners six months in advance"*

To conserve and to restore…

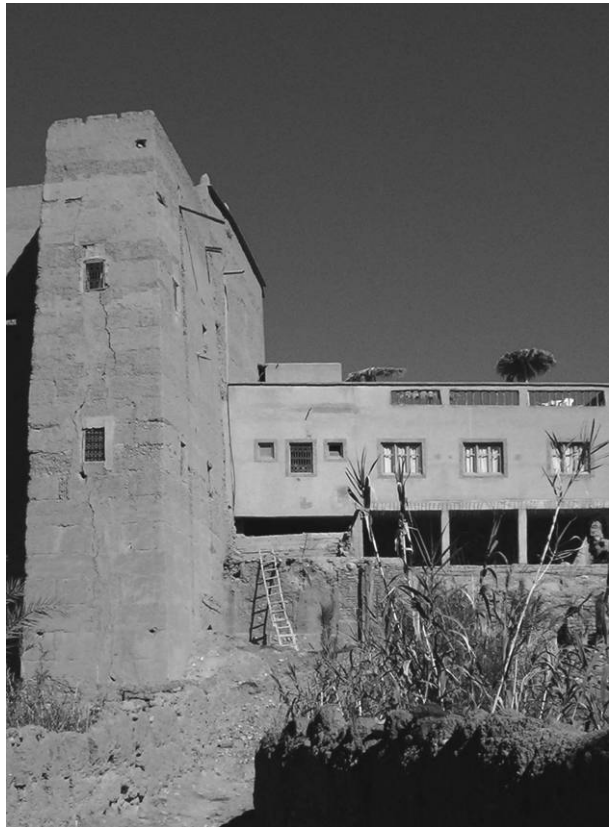
- Conserve traditional materials and techniques
- Ask for the assistance of maalems for maintenance
- Conserve original wood joinery
- Conserve the decorations



Kasbah restored by the CERKAS, at Ait Benhaddou

… But not to modify

- Do not modify the shape of existing buildings
- Get inspired from traditional architecture when constructing new buildings (volumes, heights, openings, decorations….)
- Reconstruct using traditional materials and techniques



Example of new construction altering the nature of the site.

3.2. Use and function

The best conserved buildings within the *Kasbahs* and the *Ksours* are generally those that have been adapted to a new function (office building, hotel, museum…). This shows that a change of the function of a building can put new life into an abandoned heritage, while generating the necessary funds for the proper maintenance of the structures. On the other hand, it is important to measure the real architectural impact of rehabilitation, since a change of function can often induce a radical alteration of the interior spaces. In this case,

- it is important to try to preserve the exterior of the building, its shape, its openings and decorations. The physical transformation of a dwelling put to a new use should limit itself to the interior and private spaces. It is necessary to make sure that:
  - No reconstruction using foreign materials is done
  - No modification of the openings is made
  - No metal joineries are installed
  - No destruction of the decorations is made
  - No sand-cement coatings are applied

All transformations should be made with the preliminary consultation of the State services in charge (see list on chapter 4.4.).

The enhancement in terms of comfort and the adaptation of the structures to modern living should be taken into consideration in rehabilitation projects. The conservation of the values of the heritage should not keep the population from getting access to the advantages of city life:

- Running water
- Electricity
- Interior spaces well isolated and free from dust

However, these enhancements should not bring along a dramatic change of the urban landscape, or affect the values of the heritage.

To change the use of a building (conversion) while preserving the regional architectural values

Internal volumes can be modified, but:

- Without altering the shape of exterior openings
- While respecting the shape of the original opening when creating new openings
- By avoiding the installation of metallic joineries
- By avoiding the destruction of decorative elements
- By avoiding the use of materials different from those used in the original constructions
- By avoiding the use of sand-cement coatings

Taourirt Kasbah house, converted into a hotel. Internal transformations are not visible from the outside. Architectural values are preserved.

Recent construction (hotel) in Agdz inspired from local traditional architecture (window details, decorations).

3.3. Construction materials: rammed earth, adobe or concrete blocks?

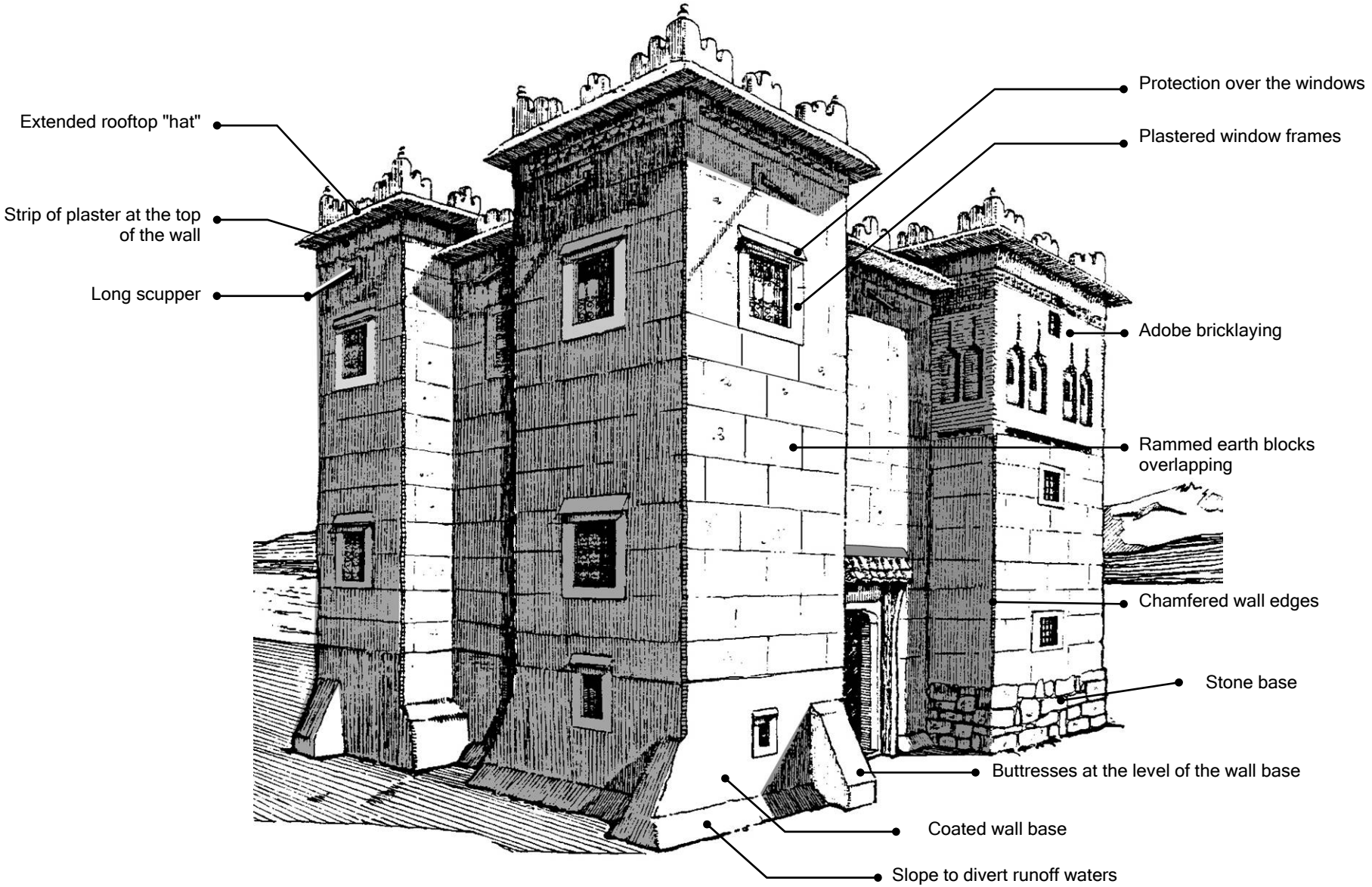
It is true that traditional materials and techniques require regular maintenance, but they have also stood the test of time, and are often more resistant than contemporary materials and techniques. Many details of traditional architecture, using local resources, allow for the protection of earth structures.

Some examples are:

- Wall bases built in stone and earth mortar
- The extended "hat" over the parapet wall, built in earth and reeds
- The covering of terraces with earth and *dess*
- The long roof scuppers
- The tall taddelakt-coated water channels

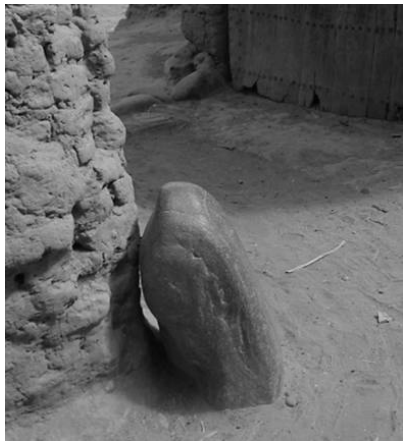
For reasons relative to thermal comfort, durability, and the respect of architectural values, it is preferable to stick to ancestral construction techniques. This does not mean that cement, asphalt or any other material on sale today should be rejected, but it is necessary to be careful when choosing them, knowing that their use can be destructive in the long run.

Theoretical diagram of a resistant building design



Details inspired from traditional architecture

- coated wall bases
- plastered window frames
- extended roof-top « hats »
- long taddelakt-coated water channels
- long roof scuppers
  etc…



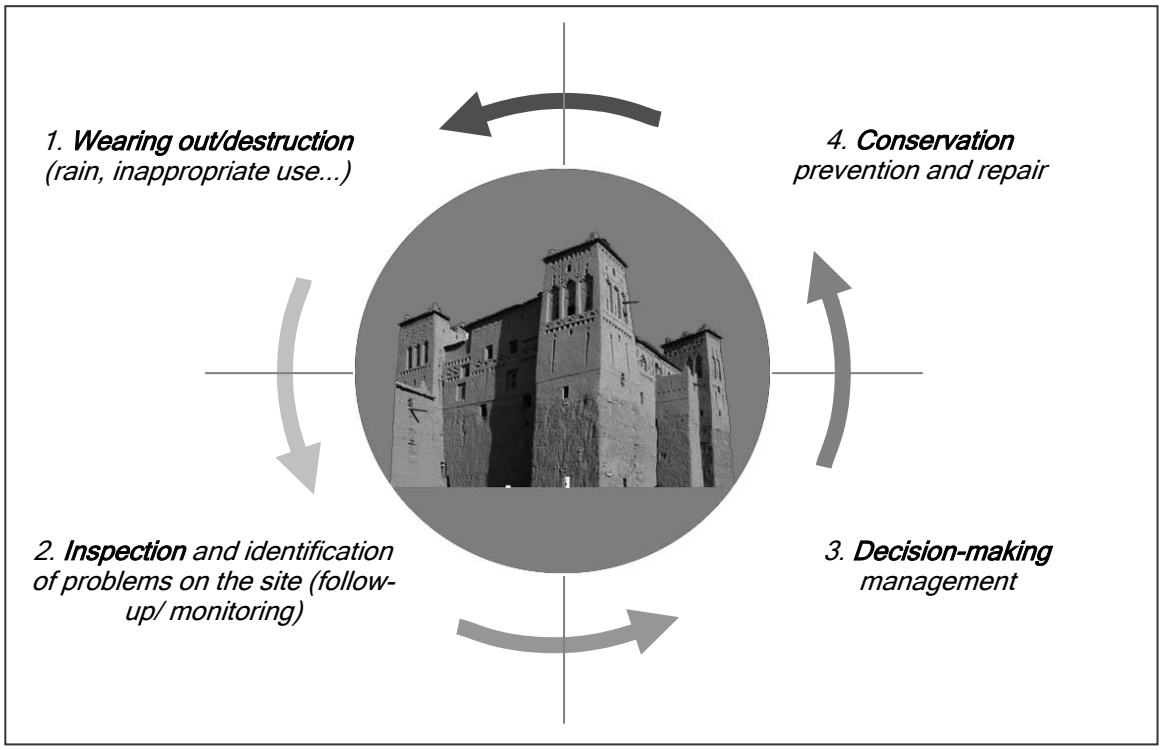
Modern solutions often inappropriate

- Cement-based coatings that don't adhere
- Chemically-stabilized plasters that don't stick
- Asphalt-based surface treatments that do not stand the heat, and that entail water infiltrations

4. Management and planning

The conservation of immovable heritage requires some management.
This necessary management can be understood as the consequence of a series of cyclical actions:

1. **Wearing out**: passive phase during which the structures are worn out due to natural or human degradation factors.
2. **Inspection/identification**: a yearly inspection of the buildings allows for a regular technical diagnosis (problem identification) and the updated listing of needs in terms of conservation.
3. **Decision-making**: Collected information following the inspection can be used to establish a list of priorities and to make the right decision in accordance with the available means and funds.
4. **Conservation**: preventive conservation works and small repairs allow for a good maintenance of the structures, while strengthening their resistance against the factors of degradation.



Conservation cycle
Conservation is a cyclical process that requires regular inspection and maintenance of the buildings.
Every year, especially at the beginning of the rain season, earth architectures should be controlled and repaired if needed (roof repair, coating of exterior walls, fixing of cracks on walls…). If a conservation cycle is interrupted, and regular maintenance is not provided any more, severe degradation can occur. The global repair of a building can then become a very costly operation.

4.1. Monitoring

An appropriate management of immovable heritage implies an accurate knowledge of its condition. Thus, it is important to monitor the structures in order to identify degradations and to foresee eventual problems. Regular visits are needed to follow-up the evolution of buildings and measure the risk of degradation.

The most important elements to be inspected during the monitoring visits are those that ensure the structure's protection against moisture: the bases of walls, the plasters, the surfaces of the roofs, the parapet walls, the window frames, etc…

4.2. Action planning

A lack of financial means often makes the decision-making process difficult, since all the necessary actions to ensure a perfect conservation cannot be taken. It is thus necessary to establish a list of priorities, in order to put the available funds to the best possible use. The information collected during the inspections should make the decision-making process possible. To plan means, first and foremost, to establish a list of actions to be taken, and to classify these actions into a list of priorities.

4.3. Recording and documentation

For every step taken, it is important to gather proofs for all completed actions. Every document, whether it is an estimate, photographs, or a technical report, can prove to be useful at some point in time. Without these archived documents, it is not possible to analyze the evolution of a given heritage, or to learn lessons from past actions.

4.4. State and Local Authorities services

Certain State services can help you through the various steps of a project (building permit preparation, technical and financial setting up of a project, choice of materials, setting and follow-up of construction works, etc.) :

Organization	Where to find it?	Function / possible types of assistance
Ministry of Culture	1, rue Ghandi, Rabat http://www.minculture.gov.ma	Site listing and help with the financial setting of projects
Delegation of the Ministry of Culture, Errachidia	Boulevard des Alaouites Océan, Errachidia Tél/fax: 055 57 35 39	Delegation in charge of the Valley of Ziz. Project controlling.
Delegation of the Ministry of Culture, Ouarzazate	Boulevard des Almohades B.P. 57 Ouarzazate 45 000 Tél/fax: 044 88 29 73	Local representation of the Ministry of Culture.
Center for Conservation and Rehabilitation of the architectural Heritage of the Atlas and sub-Atlas zones CERKAS	Tel/fax: +212 (0)44 88 30 47 Kasbah Taourirt BP 253 Ouarzazate	Linking with trained professionals (*Mâalems*) Help with the design and the implementation of conservation projects Rent of scaffolds
Ministerial Delegation in charge of Habitat and Urbanism	Angle rues Al Jaouz et Al Joumaiz, Hay Riad, Rabat http://www.mhu.gov.ma	Technical advice for construction permits
Ouarzazate-Zagora Urban Agency (Ministerial Delegation Agency in charge of Habitat and Urbanism)	Siège : boulevard Mohamed VI, Près du siège de la Province B.P. 290, Ouarazazte Tél. :044 88 25 90 Fax : 044 88 21 47	Technical advice for construction permits in the region of Ouarzazate
Laboratoire Public d'Etudes et d'Essais LPEE	Bureau central : 25, rue d'Azilal Casablanca 20 000 Tél. :022 54 75 75 ou 54 75 99 Fax : 022 30 15 50 Bureau de Ouarzazate N°6, quartier industriel, Ouarzazate 45000 Tél : 044 88 51 81	Analysis of construction materials Private laboratory (private services)
Ecole National d'Architecture ENA	B.P. 6372 Rabat Institut Rabat Tél. : 037 77 52 67 Fax : 037 77 52 76 e-mail : ena@ecole-archi.net.ma	Higher education institution in the field of architecture. This school offers courses related to Heritage, with internship possibilities for students.
International Council on Monuments and Sites - ICOMOS Moroccan Commitee	Secrétariat national, Ecole National d'Architecture Rabat Institut Tél. : 037 77 52 29 Fax : 037 77 52 76	Ensure the State's monitoring of the state of conservation of listed monuments Sensitize the general public about the protection, the safeguard and the restoration of sites and monuments Initiate projects in the fields of conservation and restoration
Ouarzazate Province Urbanism Division	B.P. 74 Ouarzazate 45000 Tél : 044 88 22 18 poste 236 ou 256	Technical advice for projects on protected zones Contact : El Mamoun ZAGROUJ, Architect -specialist in earth architecture. (email : elmam10@yahoo.fr)

5. Production of materials

Earth selection

This manual does not explain how to recognize an earth that can be used in the construction of a rammed earth wall, or one that is appropriate for the application of an earth plaster. Quality soils are easily available in the Drââ valley, and most of the traditional artisans of the area know how to select the soils that are appropriate for the production of adobes, the construction of a rammed earth wall or the application of an earth plaster. However, this know-how is gradually disappearing, and it is necessary to be careful when choosing a soil for construction purposes. In the absence of *mâalems*, it is possible to seek the assistance of the village's elders, who can sometimes indicate the locations where "good" soils can be extracted. Soils that are unsuitable for construction purposes are those that are found on the surface and that contain organic matter, polluted soils (soils containing waste or rubble), or those contaminated by latrines.

It is recommended that people without knowledge of traditional construction methods, such as architects who have been trained to master contemporary construction techniques, or foreign investors who have settled on the valley, ask for the assistance of experienced artisans (*mâalems*), to guide them in the selection of the materials. A visit of the buildings they have built in the past can be useful to evaluate their skills.

Adobe production

Mixing of the earth

Moulding of the adobes

Reconstruction of rammed earth walls

As for the selection of soils, the construction technique for rammed earth is not explained in detail on this manual. Again, we recommend to seek the assistance of a *mâalem* or the reconstruction of rammed earth walls, or to seek the advice of the Cerkas.

Installation of a formwork for rammed earth

Wetting and mixing of the earth

Carrying the earth up to the formwork

Pouring the earth into the formwork

Leveling the earth

Ramming

Evolution of the construction

6. Conservation works

What to keep, what to destroy?

For every intervention on an earth building in the area, it is important to preserve all the elements that are still in good condition. This rule applies to constructive details as well, such as decorations or the types of openings that contribute to the unique character of this architecture. As we specified in chapter 3, it is important to preserve all that is still holding. When a wall is partially destroyed, but the rest of the structure is not weakened, it suffices to rebuild the missing portion. If an entire element is weakened, a wall for example, it is preferable to destroy it completely and to rebuild it from the base up, using the same technique, or at least the same material.

The soil found on ruins can also be recycled, if it has not been too washed out by the rains. For small repairs, rammed earth walls can be rebuilt using adobe bricks.

6.1. Homogeneity of materials

The addition of structures using new materials, such as frameworks made out of steel or reinforced concrete, is dangerous. The violent earthquakes that affected the city of Bam, in Iran, in late 2003, and Al Hoceima in Morocco, in February 2004, have once again demonstrated the fragility of mixed structures, which generate conflicting material behaviours that can cause foldings, discharges, breakings and collapses. Homogenous structures built in earth alone have a much better resistance, as long as they are well built and well maintained.

Example of a structural reinforcement attempt. This type of reinforcement should be avoided, since a non-homogenous structure has a lesser resistance against earthquakes.

6.2. Temporary protections

When part of the building threatens to collapse, and the necessary means for its protection are not immediately available, it can be possible to protect it temporarily.
Temporary protective solutions can significantly reduce the cost of future reparations, while keeping the structure from falling apart too soon.

Propping up

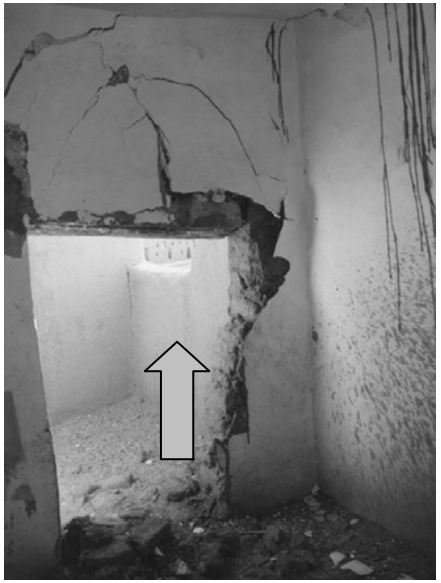
Earth structures often degrade themselves from the interior, when roofs start to leak. Water infiltrations erode load-bearing structures, which give way on their weak points: beam to wall joints, lintels, etc…
Propping up consists in providing temporary support for elements threatening to collapse.

Covering

A waterproof canvas sheet can suffice to keep an infiltration from further degrading a perforated roof. It is however necessary to ensure a proper water run-off towards the roof scupper, without generating specific erosions. A waterproof canvas sheet that would fill up with water, without the proper evacuation, would entail a dangerous overload of the roof.

Drainage trenches

Before clearing a lane blocked by rubble, it is possible to dig a temporary trench, which will allow for the rainwaters to run-off. This will make it possible to prevent the formation of new moisture-related pathologies on adjacent buildings, while the lane is being completely cleared.



Example of a structure that needs to be propped-up

Wood and steel structure, temporarily holding a cracked wall

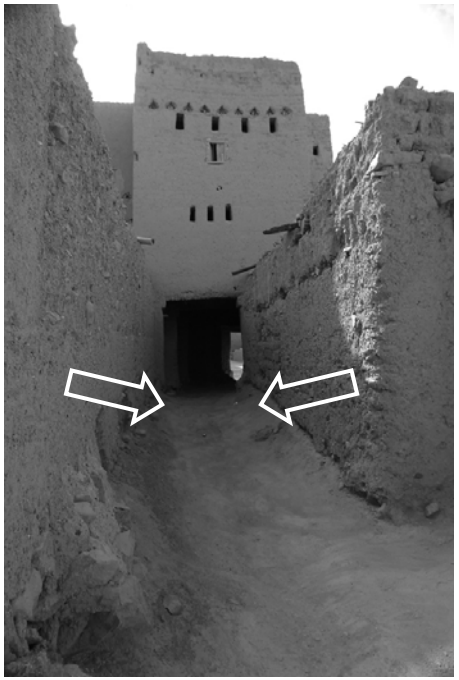
6.3. Drainage

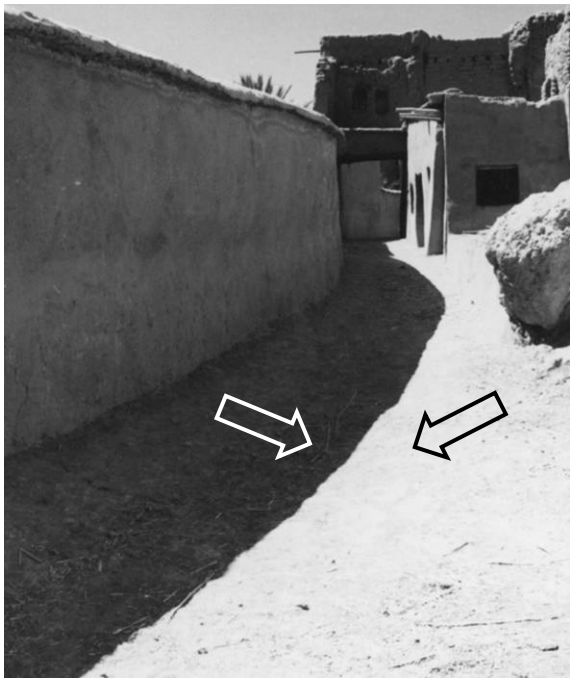
Moisture is one of the main factors of degradation. Everything must be done to drain the water away from earth constructions. Surface drainage consists in directing the waters to places where they are less likely to damage the structures. Drainage is usually ensured by a slope on the ground that directs the water towards a specific area. A shallow slope of less than 5% is enough to guarantee the water run-off. A slope too steep can generate an acceleration of the water runoff, and an increased erosion of the ground surfaces. When the topography does not allow the creation of shallow slopes, ground surfaces should be treated with gravels.

Drainage slopes are necessary on :

- Flat roofs
- Lanes
- Courtyards

Example of an improperly drained flat roof





Examples of properly drained lanes

Creation of shallow slopes on a courtyard, to direct the water away from the walls.
The tensed strings are used as references to arrange the layers of earth into a regular slope.

Shaping of earth draining slopes, around an enclosure wall.
Moist earth is spread and then packed down manually in layers, as it is done when constructing rammed earth buildings.

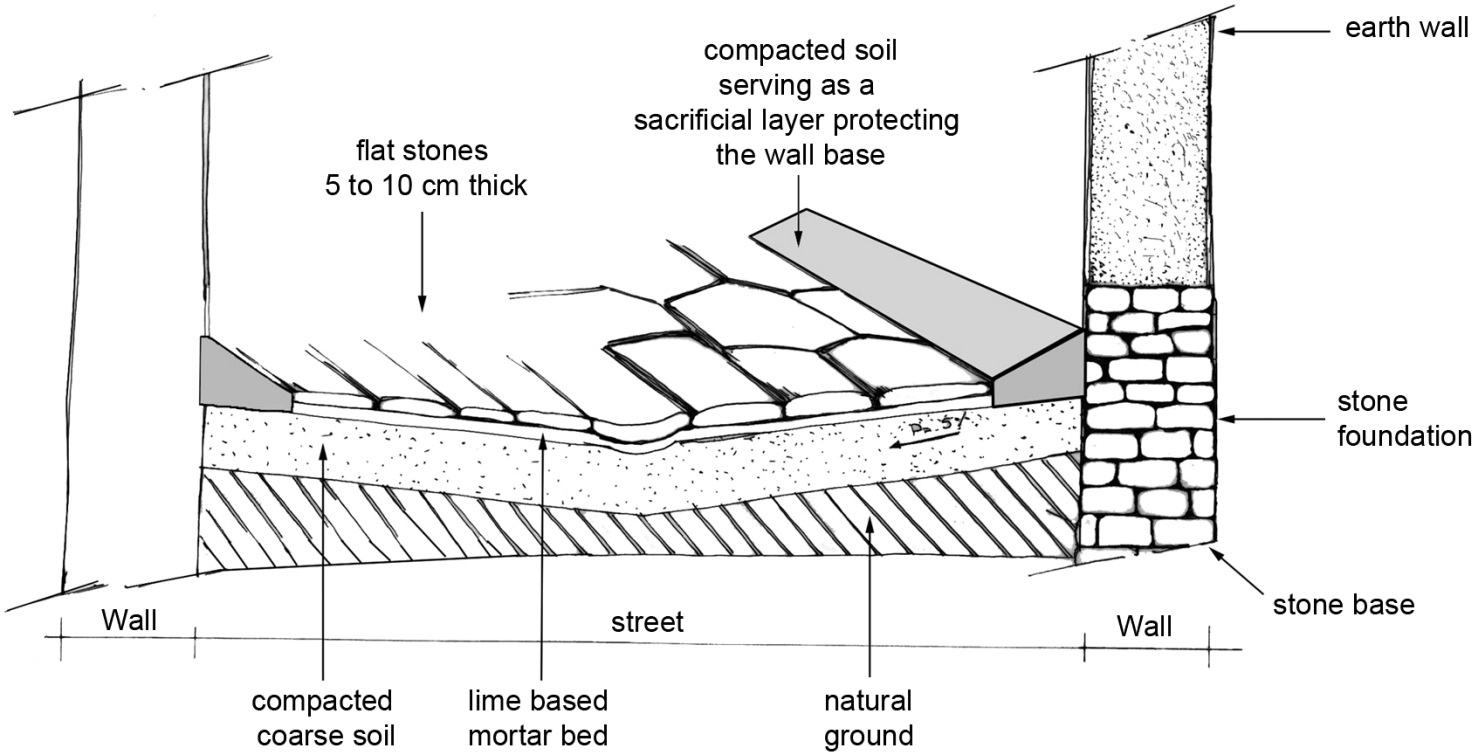
6.4. Lane paving

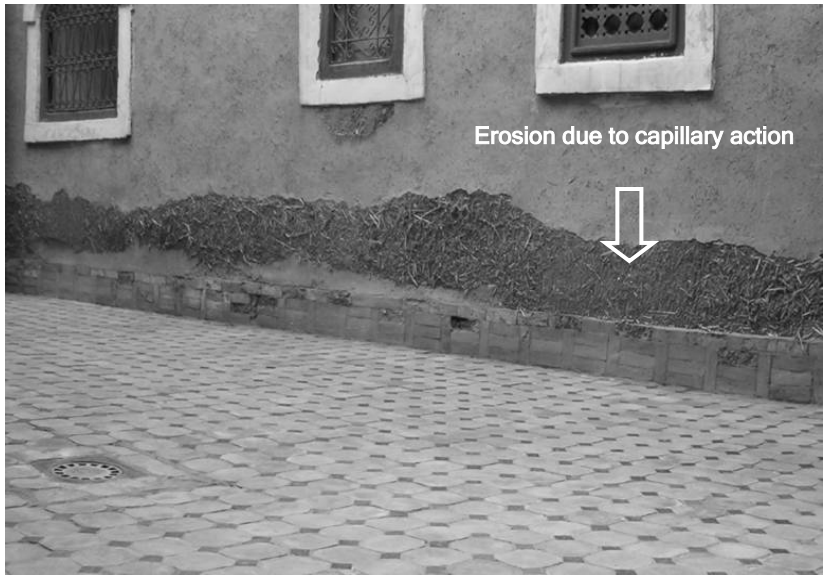
Paving of alleys and lanes using flat stones makes it possible to:

- make lanes practicable for pedestrians when it rains, particularly in the case of narrow and steep lanes
- guarantee a proper water drainage while slowing down the erosion process of the ground surface
- avoid water infiltrations on lateral walls

Some precautions should be taken for their implementation:

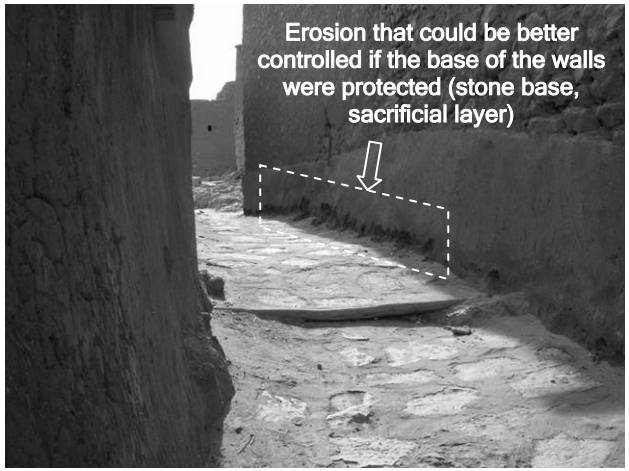
- the ground surface should be curved, in order to allow the water to be directed towards the center of the lane
- the mortar used should be porous enough to allow the moisture evaporation from the ground
- the compacted earth on which the paving is done should not be too sandy, if we want the moisture to evaporate vertically through the paving and not through the lateral walls

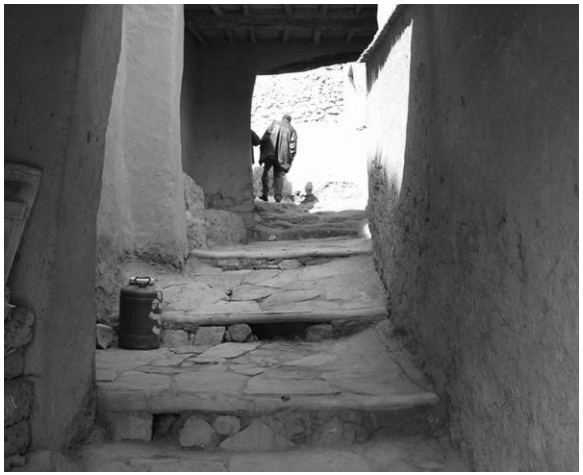




Waterproof pavings such as cement screeds or terracotta prove to be destructive for the buildings, since they promote the capillary action on the surrounding walls.

Lane paved with flat stones

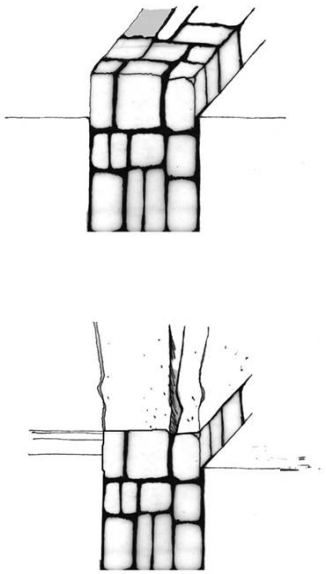




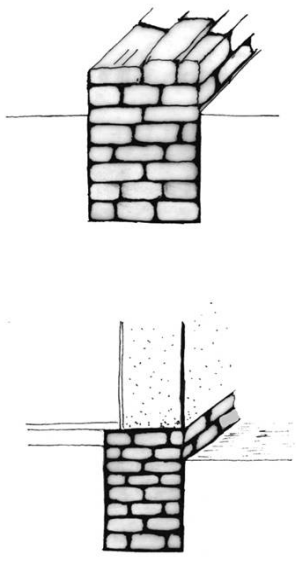
Lanes and stairs paved with flat stones, with central drainage slopes

6.5. Insertion of foundations

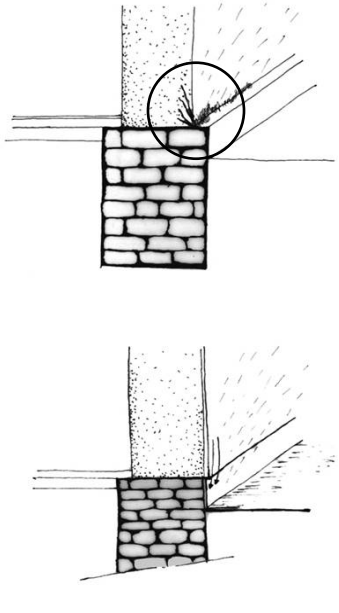
The foundation and the base of the wall play a significant role. They guarantee, among other things, that the loads are properly distributed on the ground, and that moisture does not go up into the walls.
A building without a stone foundation is not necessarily a fragile or at risk of becoming fragile. A proper peripheral drainage already offers good guarantees for the stability and the durability of a building. But sometimes the foundations are too superficial and cannot guarantee that a building is stable, particularly on weak grounds, sensitive to moisture. In this case, the bases can be reinforced through the insertion of a stone foundation. This is possible while operating in small sections of approximately one meter at a time. Such an implementation is not without danger. It should be done outside the rain seasons, and the wall should be propped-up to ensure the protection of the workers.



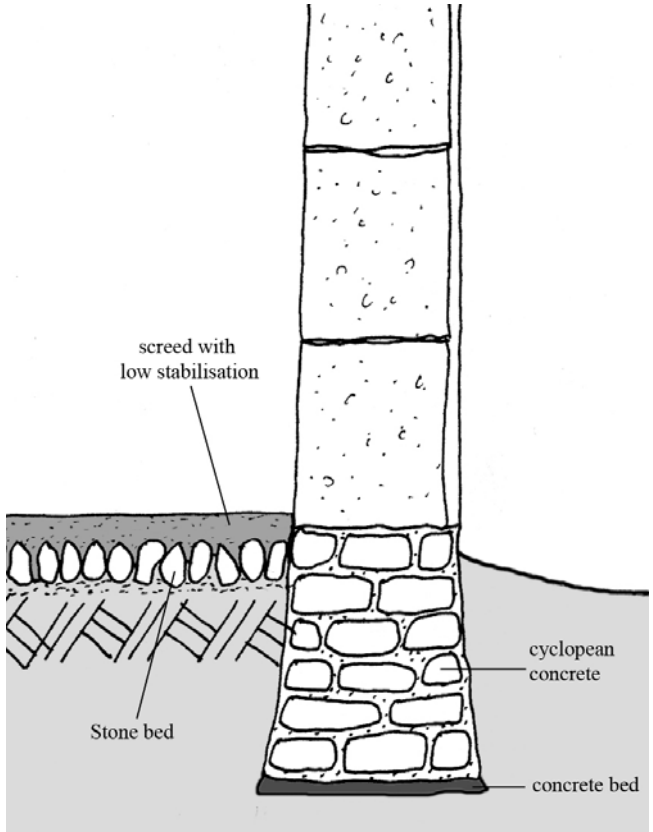
A vertical or an oblique stone laying can generate cracks on the walls

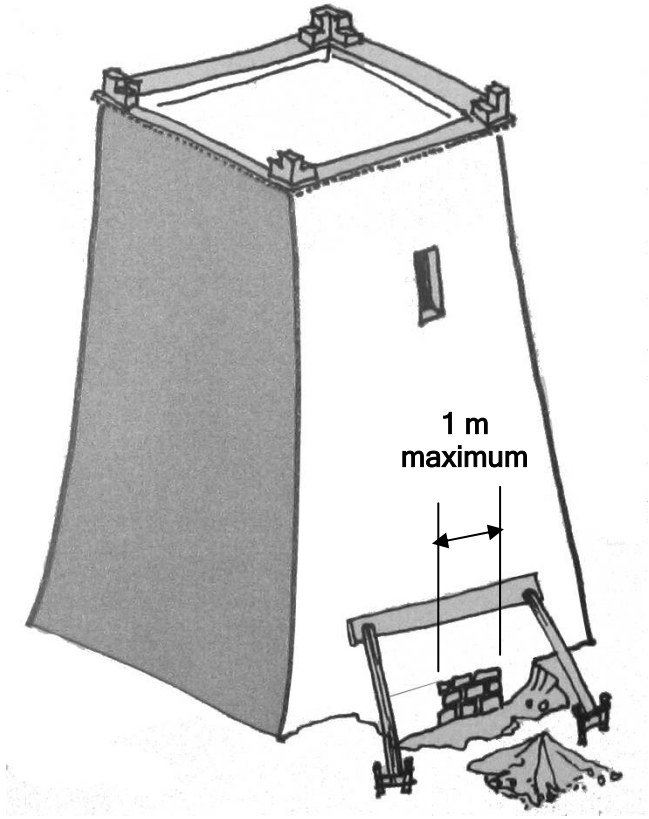


The stones should be laid on their flat side

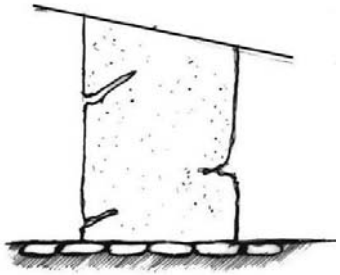


To avoid infiltrations at the base, the stones should be laid following the vertical surface of the wall.

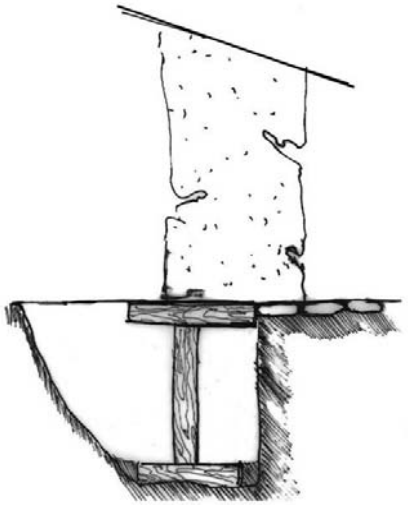




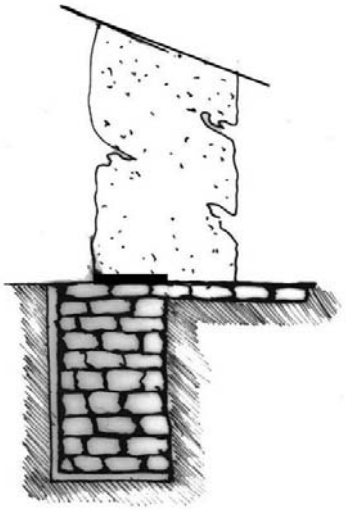
Insertion of a new foundation by working on one-meter sections. To implement longer sections could cause the collapse of the building.



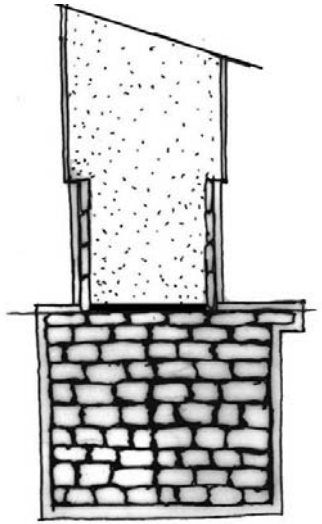
1. A wall without a foundation



2. Clearing of the space under the wall (only as deep as half of its thickness) and on one-meter sections maximum, then propping up.



3. Construction of a stone foundation, and insertion of a capillary barrier under the wall.



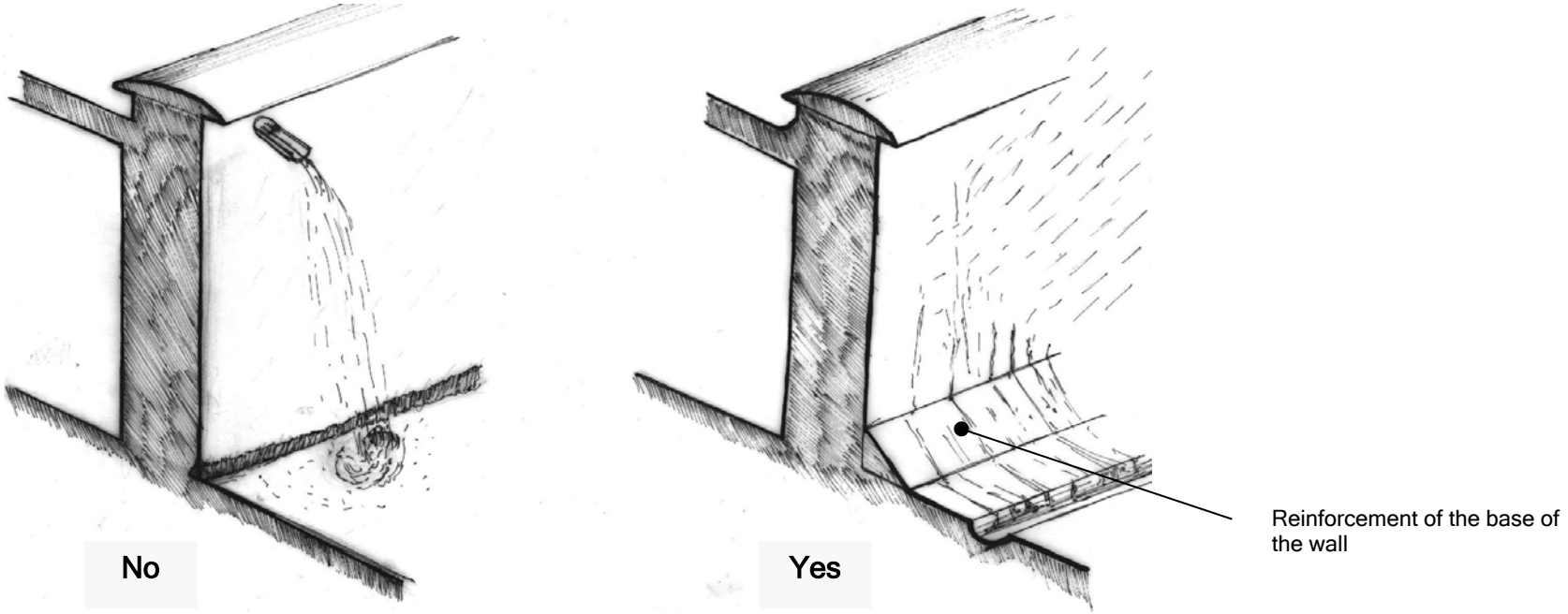
4. Construction of the second half of the foundation, same principle of implementation.

6.6. Reinforcement of the bases of walls

The foundations at the base of the wall play an important role. They guarantee, among other things, that the loads are properly distributed on the ground. The base of the wall erodes more quickly than the rest of the wall, for various reasons:

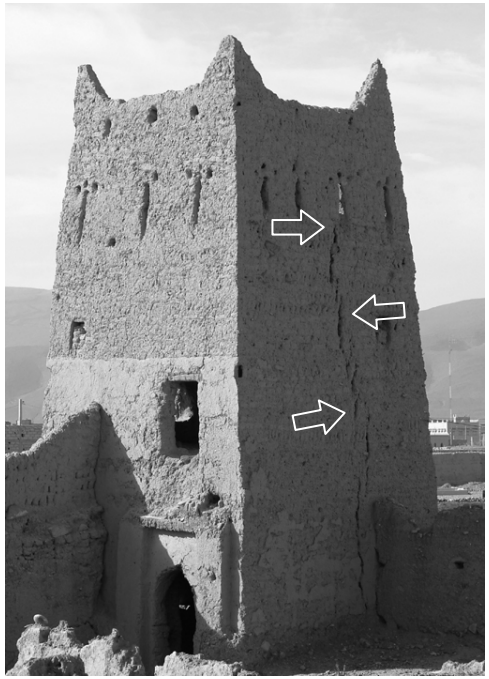
- Erosion due to the water pouring from roof scuppers
- Erosion due to water streamings along the walls
- Significant capillary action, entailing erosions related to the wind and the rain
- Capillary action involving an erosion due to the crystallisation of dissolved salts

When the base of a wall is too exposed to water projections, along a road for example, it is possible to reinforce it (drawing on the right), or to line it with flat stones (photographs on next page).



Reinforcement of the base of a wall through the implementation of a stone lining

6.7. Monitoring and treatment of cracks



A crack signifies a structural deformation. All cracks should not be deemed dangerous. To measure the potential threat linked to a crack, it is necessary to check if the crack evolves (living crack), or if, on the contrary, it signifies a problem that has stabilized. (dead crack). To verify if a crack is “living” or “dead”, it is recommended to monitor it over several months. One or more plaster pads placed over the crack will help determine the evolution of a given crack.

To treat a crack without first eliminating the cause of the deformation does not bring a solution to a problem. It is thus necessary to understand what caused the creation of a given crack, by analysing the deformed element on a large scale. The cause for a deformation can be found far from the crack, at the base of the building, for example. The deformation is generally due to the accumulation of water at the base of the building, following an accidental change in the topography (collapse of a wall, material deposits or waste deposits, etc.)

Before treating a crack, it is always necessary to:

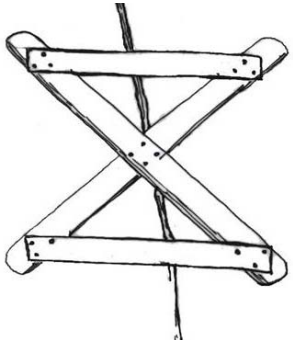
- Observe the crack to know if it is « living » or « dead », by placing a plaster pad over it (see photograph on the right). The monitoring should be done over a period of several months, preferably through weekly inspections.
- If the crack is « living », that is, if its shape and size evolves, the cause of cracking should be identified and located.
- Eliminate the problem by dealing with it right from its root, making sure not to generate a new problem.
- Make sure that the structure is stabilized after the treatment of the crack, by placing a plaster pad over it. The stabilization can take several weeks after the treatment.
- To treat the crack (see next page).

Plaster pad placed on a vertical crack

Filling of a « dead » crack

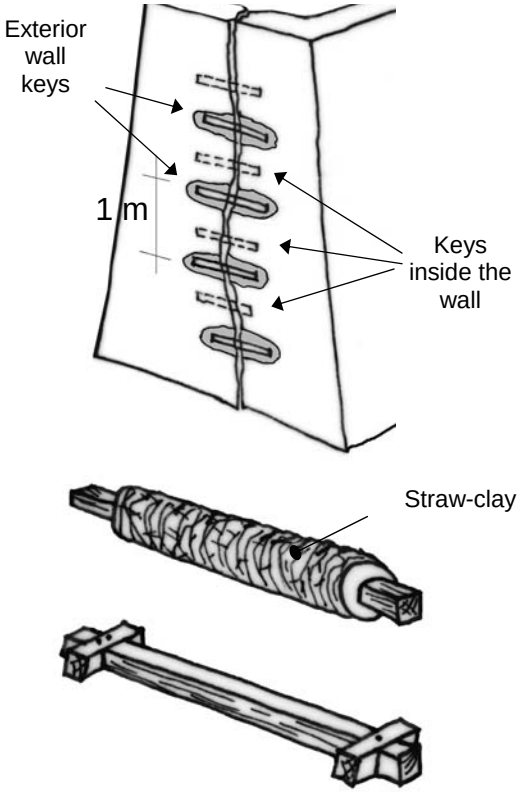
Once the structure is perfectly stabilized, it is possible to:

- Clean the crack to remove dust particles.
- Insert the wooden keys into the wall, scealing them with earth or with gypsum, at least 15 cm deep into the masonry.



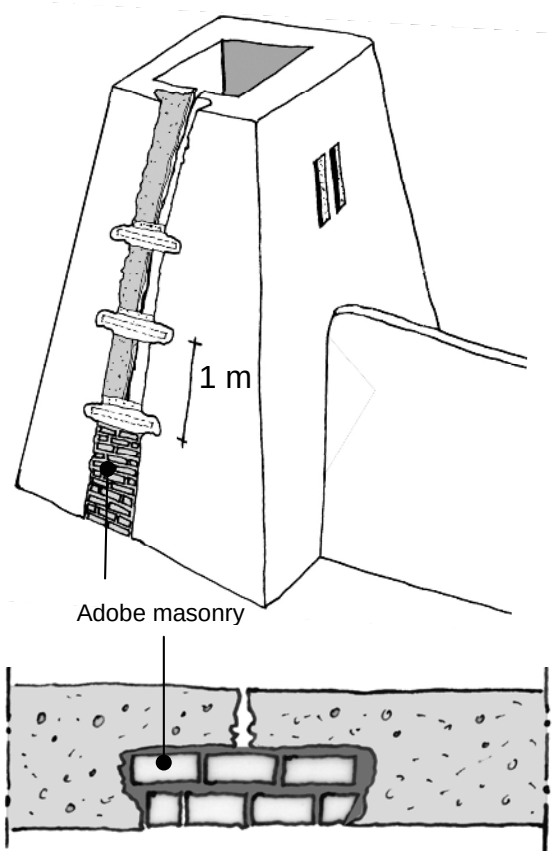
X-shaped wooden keys :

This solution has been tested by the Cerkas, but it involves deep cuts into the walls, and it can further destabilize structures that are already weak.



Horizontal wooden keys :

This solution consists in the stitching of the wall, through the insertion of keys every 50 cm., alternating their implementation, once on the outside, once on the inside of the wall.
The keys are scealed with gypsum or with an earth based mortar. This type of key can be made out of wood covered with straw-clay, or in wood alone.
The lenght of each key will be one meter minimum.



Rebuilding the wall around the crack

Once the wall is stitched, it can be filled-in. To avoid the reproduction of the cracks, it is recommended to make repairs using adobe bricks rather than a humid soil, thus minimizing the shrinking effect during the setting process.

6.8. Reiforcement of the brickwork through the insertion of poles and ring beams

Ancient houses have stood the test of time for centuries, often without suffering from structural deformations. The insertion of clamping elements if often useless, even when the building is cracked. As we have explained earlier, a cracked building should be first stabilized, while eliminating the causes for deformation. Once the structure is stabilized, and the cracks treated, additional structural reinforcement is rarely needed. Deep carving of a cracked structure to insert concrete beams or large wooden pieces can be a very dangerous operation, and can put the lives of construction workers at risk.

The insertion of poles in the corners of the building should also be avoided, since it weakens the monolithic earth structures, and can cause deformations on the angles.

Only the insertion of a ring beam, the use of tie rods or butresses can be justified in some cases. Generally speaking, it is always best to develop constructive solutions using wood, a material that works well in combination with earth, better than steel or concrete. Every solution must be carefully considered before being implemented.

- **Tie rods**
  Transversal ties, binding two opposite facades of a building, allow for the reconnection of a structure that has been divided into two parts, and of which one part is deformed. The insertion of a rie rod can prevent the collapse of a severely deformed wall.

- **Peripheral clamping**
  The implementation of a peripheral clamping is interesting when a structure has been fragmented into several elements, following significant deformations. It allows the reconnection of all the fragmented parts of the building, for a better load distribution within the structure.

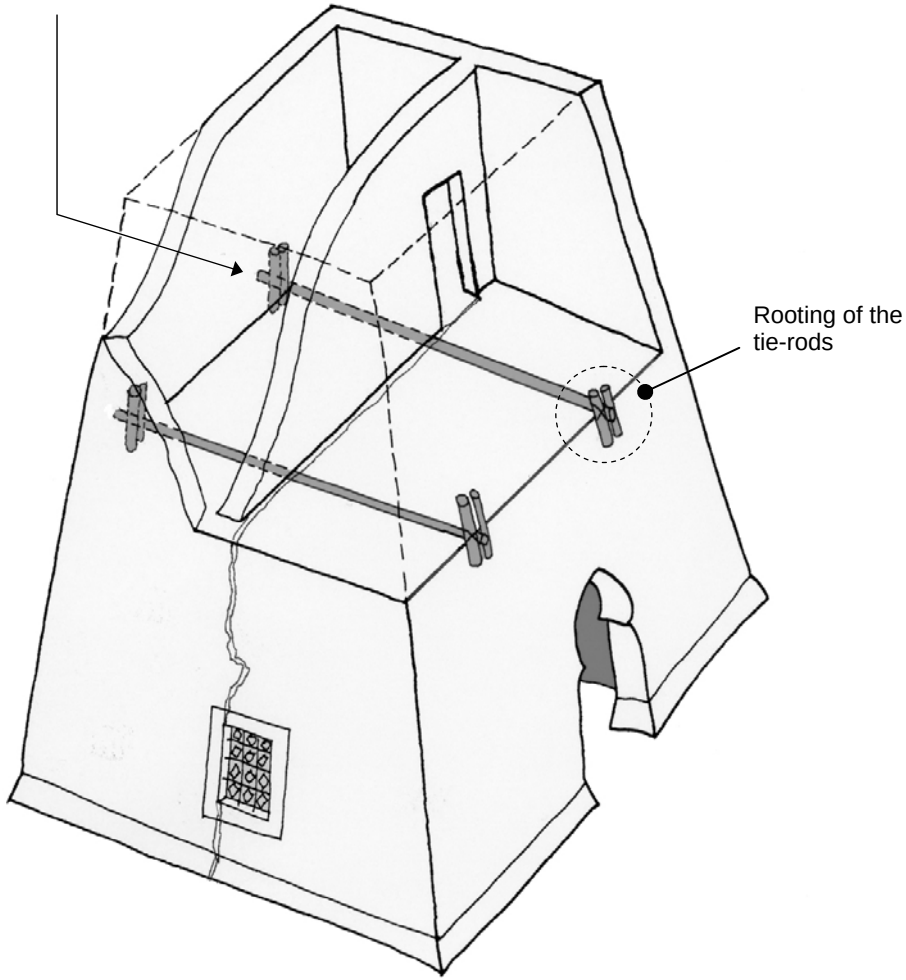
What does the law state?

During the reconversion of earth houses into lodgings, the engeneering departments often require the insertion of concrete structures, in the name of security. As it has been previously explained, the insertion of concrete elements is generally useless, and van even prove to be dangerous in the event of a seism. These heavy solutions are not adapted at all to the true qualities of earth construction materials, and can produce contradictory structural behaviours.

The law does not state anything in particular on this point. The insertion of concrete framings in restoration works is not required by the law.

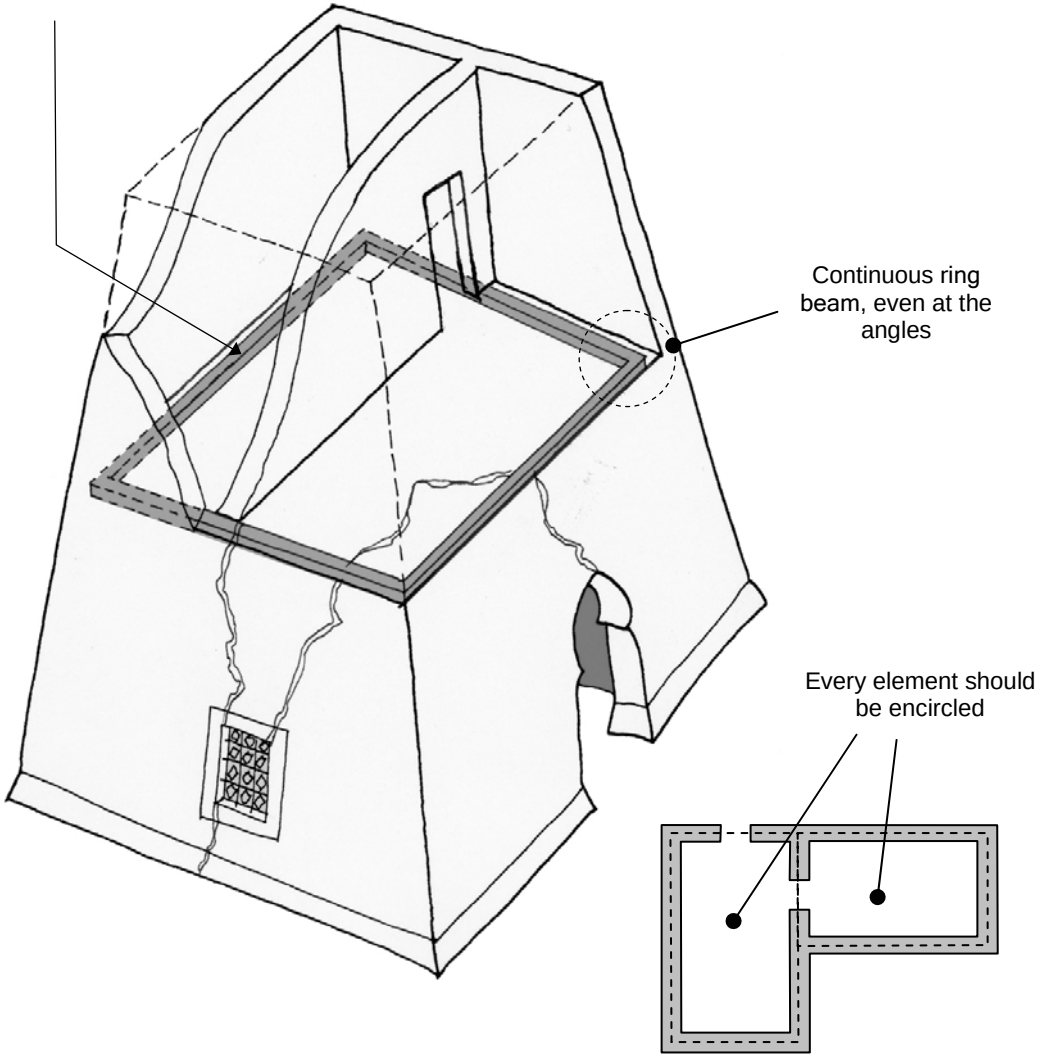
Transversal ties :

The insertion of transversal ties allows for the retention of a structure that has been divided into many elements, following a deformation.



Ring beam :

The insertion of a ring beam is necessary only when a structure has been divided into many parts, following a significant deformation. All ring beam elements should be joined at the angles, and thering beam should have a square or a rectangular shape. An open ring beam (on three sides only), or weak angle joints, or even a polygonal ring beam (5-6 sides) is not effective.



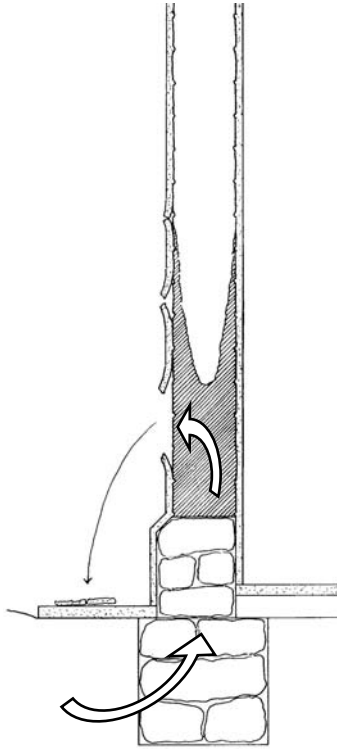
6.9. Exterior wall-coatings

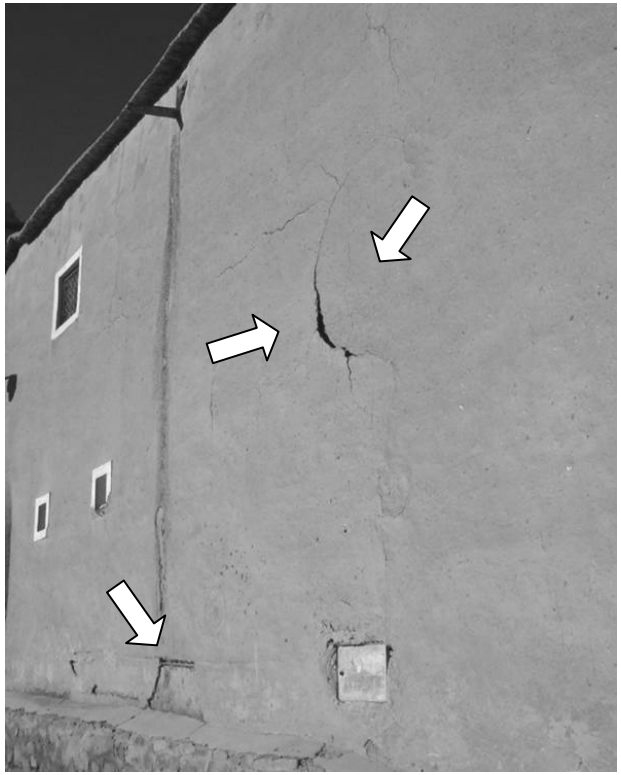
Beware, sand-cement coatings are dangerous !

Modern surface protections that are too visible nowadays, such as sand-cement, glues or resins, have proved to provide only a temporary protection of earth structures, while potentially causing great damage and great expenses in the long run. Their physical and chemical properties keep them from properly and durably adhering to raw earth surfaces. Moreover, their use can worsen the pathologies linked to moisture for lack of porosity. Their use should be avoided, whether it is for the coating of vertical or horizontal surfaces. For a stabilized coating to properly adhere to an earth wall, it should make moisture exchanges possible. Gypsum and lime are some of the stabilizing agents that are compatible with earth materials, since they allow for the walls to breathe.

Defects of stabilized waterproof coatings:

- Retention of the moisture absorbed through capillary action
- Moisture retention at the base of the wall
- Loss of cohesion of the earth material
- Reduction of the resistance of the structure
- Separation and cracking of the coating
- Degradation of the coating, which falls off
- Degradation of the wall



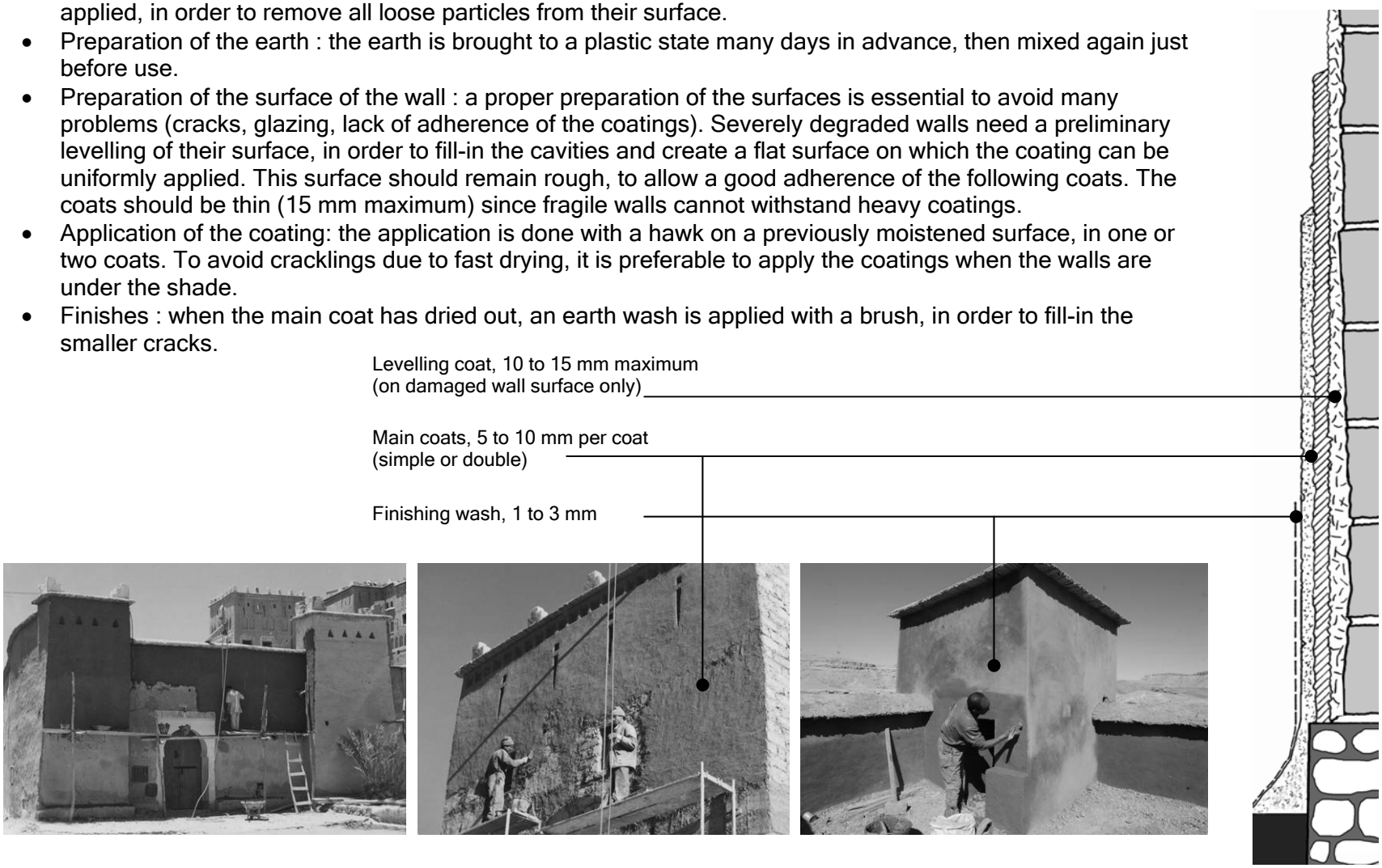


Stabilized waterproof coatings keep the moisture absorbed through capillary action from evaporating. They end up separating from the wall, crackling and falling apart.

Exterior earth coating

The application of an exterior earth coating is done in five steps :

- Cleaning of the wall : the walls should be scraped, dusted and abundantly moistened before the coating is applied, in order to remove all loose particles from their surface.
- Preparation of the earth : the earth is brought to a plastic state many days in advance, then mixed again just before use.
- Preparation of the surface of the wall : a proper preparation of the surfaces is essential to avoid many problems (cracks, glazing, lack of adherence of the coatings). Severely degraded walls need a preliminary levelling of their surface, in order to fill-in the cavities and create a flat surface on which the coating can be uniformly applied. This surface should remain rough, to allow a good adherence of the following coats. The coats should be thin (15 mm maximum) since fragile walls cannot withstand heavy coatings.
- Application of the coating: the application is done with a hawk on a previously moistened surface, in one or two coats. To avoid cracklings due to fast drying, it is preferable to apply the coatings when the walls are under the shade.
- Finishes : when the main coat has dried out, an earth wash is applied with a brush, in order to fill-in the smaller cracks.



Choosing an earth for coating purposes: testing

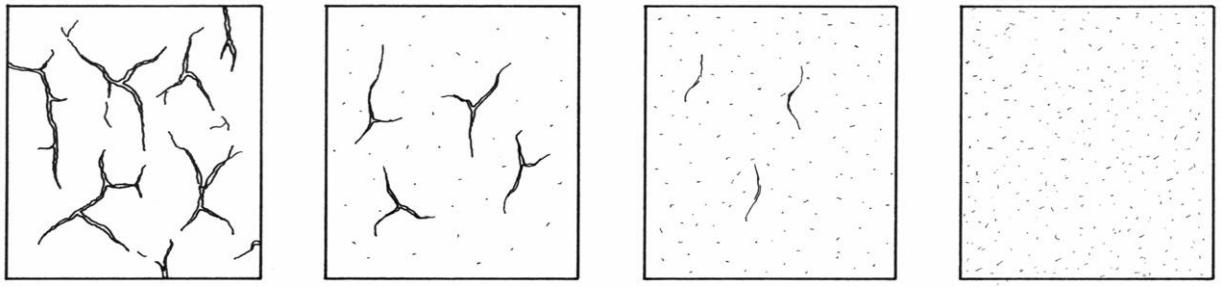
In case of hesitation about the choice of an earth suitable for coating, a simple test makes it possible to evaluate the performances of available earths, and to find the best proportioning of sand or straw to be mixed in, if there is too much clay in the soils.

Implementation of the test :

- Moisten and mix the earth samples until reaching a plastic state of the mixture. The moistening should be preferably done a few days in advance.
- If the earths have a high clay content, prepare samples of the earth mixed with different quantities of sand
- Apply the sample mixes on a cleaned and moistened surface, on 40 by 40 cm squares minimum
- Note the references for each sample
- Observe the results after complete drying

Analyzing the results :

- The chosen mix should have a good adherence to the wall
- Only a slight crackling is acceptable
- The colour of the coat should correspond to the colour of the surrounding buildings



Too much clay | Too much clay | Fair proportioning | Too much sand

6.10. Exterior wall coatings stabilized with lime

Lime is mainly used to stabilize exterior elements, such as facades, patios and parapets, in order to increase their resistance to erosion.

Implementation

The exterior wall coating is composed of three coats:

- Levelling coat (1 to 1,5 cm) : this coat is done with earth or a with a mixture of earth and sand. It will offer a better adherence if the mixture is enriched with chopped straw.
- Main coat : a thick coat of 0,5 to 1 cm. The composition of a main coat is the following : 3 parts earth/2 parts sand/1 part lime.
- Finishing coat : it is applied over the main coat when it is almost dry, making it possible to fill-in all the small cracks on the surface. The finishing coat should be very fine (2 to 3 mm). Its composition is richer than that of the main coat : 1 part earth/1 part sand/1 part lime.

Composition of a stabilized mortar

Levelling coat	Main coat	Finishing coat
• earth • sand • straw (proportions to determine according to the quality of earth)	• 3 earth • 2 sand • 1 lime	• 1 earth • 1 sand • 1 lime

6.11. Interior wall coatings

Interior coatings can be made with earth alone or with stabilized earth. Stabilization will make the surface more resistant to friction, but it is not required in dry rooms. An economically interesting option is to stabilize the finishing coat only, applying it onto a levelling coat made with earth only.

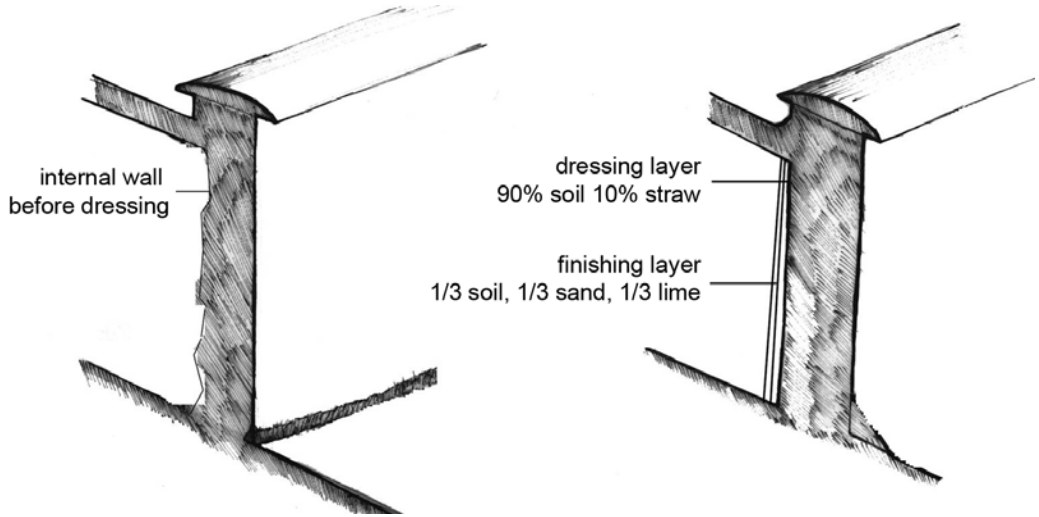
Levelling coat

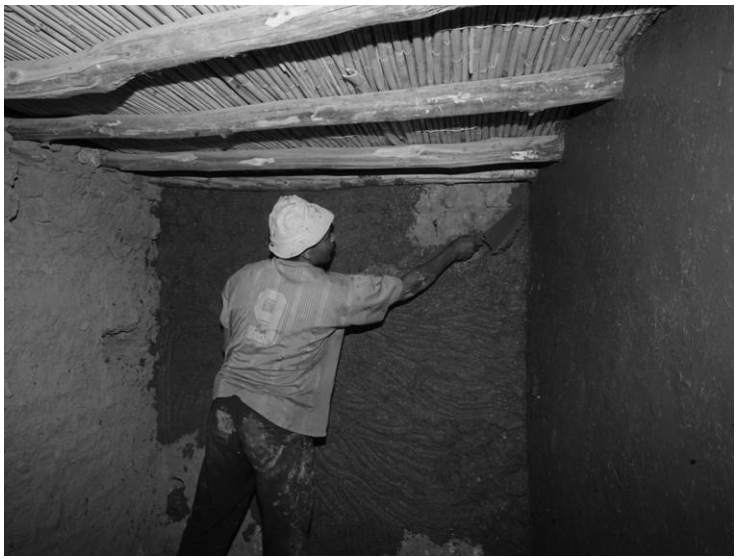
As with exterior coatings, it is advised to prepare the wall by cleaning it, and by applying a levelling coat in order to make the wall surface uniform. The levelling coat will offer a better adherence if it is enriched with chopped straw.

Interior coat stabilized with lime

To reduce the cost of stabilization, the finishing coat alone can be stabilized. This coat is applied over a levelling coat made with earth or with an earth and sand mixture. The recipe suggested here should be tested and refined according to the quality of the earth. The standard proportions for a stabilized interior finishing coat are the following :

- 1/3 earth
- 1/3 sand
- 1/3 lime





6.12. *Taddelakt* wall coatings

Taddelakt is a lime-based coating traditionally employed in hammams. Many buildings attest to the reliability and the durability of this material, that handles heat and moisture very efficiently. It can be applied on walls and on floors as well, on interior and exterior surfaces. On the other hand, this surface coating is very costly because its implementation is very long and tedious; this is why it is generally used only on water channels and on bathrooms.

Preparation:
Taddelakt is primarily composed of rustic lime and water. Rustic lime is slaked in large containers, two or three days prior to its use. It is then transformed into a paste, which can eventually be mixed with water before its application, to obtain the desired creamy consistency. As for every coating, the surface should be moistened before the implementation of the *taddelakt*. The final colouring of the *taddelakt* is given by the pigments, which are added to the mix in very small quantities.

Application:
Lime, water and pigments are mixed together so as to obtain a mortar of plastic consistency. This thick mixture is spread on a thin layer over the wall (2 to 3 mm). The coating is then hawked in a circular motion, in order to ensure a proper flattening of the mixture over the surface.

Some minutes after its implementation, the coating is hawked again in order to correct any irregularities. The flattening of the mortar, using a flexible scraper, in cedar wood or in plastic, makes it possible to take out the maximum amount of water from the mortar, while tightening its surface.

After half an hour to one hour of drying, the surface of the coating is rubbed with a pebble in a circular motion. The water released by the mortar makes the pebble slip over the surface without making it stick to it. This very long phase gives the coating its first level of hardness.

On the day following its application, the *taddelakt* is moistened again and then rubbed with a pebble, but this time around using a liquid soap (known as "*savon noir*" in French) diluted in water. The role of the soap is of primary importance as a lubricating agent, since it keeps the *taddelakt* from falling apart when coming into contact with the rubbing pebble. The soap can be replaced with the traditionally used egg yolk, which allows for the *taddelakt* to harden, but which makes its implementation more difficult. Some craftsmen add egg yolks to the soapy water.

If glazing occurs, a *taddelakt* wash is applied with a rag.

After a complete drying of several weeks, a natural wax is applied to give brilliance to the *taddelakt*.

Implementation precautions:

- Connections : It is not possible to make invisible connections. It is thus necessary to work on the totality of a given surface at once, by working in teams adapted to the size of the walls to be coated. A *mâalem* assisted by two workers can complete the work on a surface of 0.6 square meters in eight hours. 25% of the time is devoted to the preparation of the mixture and to its application, and the remaining 75% to its smoothening.

- Working outside : To implement the *taddelakt,* it is necessary to work under a shade, in order to slow down the drying process and avoid cracks due to a fast drying.

- Pigments : It is recommended to produce in advance samples of *taddelakt* of different colours, in order to evaluate the accurate quantities of pigments needed to obtain the desired colour effects.

6.13. Rebuilding floors and ceilings

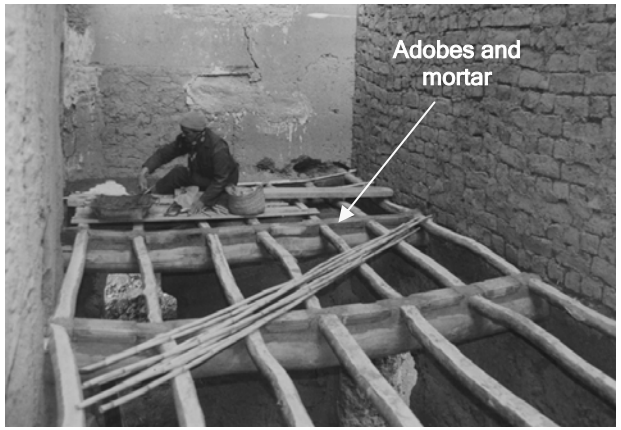
Floors consist of a wooden framework (beams, joists and rods) carrying a thick layer of earth.

Main beams are made with solid tree trunks with a diameter of approximately 20 cm. They must rest on a solid load-distributing element, or better yet on a peripheral ring beam in order not to impose a concentrated load directly above an earth wall.

Joists on the secondary framework are made out of wood pieces of smaller section (about 10 cm.), spaced every 30 cm approximately. When the beams are twisted, a layer of stones and earth makes it possible to correct deformities and to ensure the positioning of the beams at the required level. The joists are kept in place over the beams by adobe bricks, laid with an earth mortar between the joists (see photograph in the middle).

A layer of wooden rods is placed over the joists. These rods serve as permanent formwork for the earth layer. The rods can be simply juxtaposed (for simple reed ceilings) or laid out following intricate geometrical patterns (Tataoui ceilings).

Implementation of the beams



Placement of transversal joists over the beams

Placement of baytree wood rods for the implementation of a Tataoui ceiling

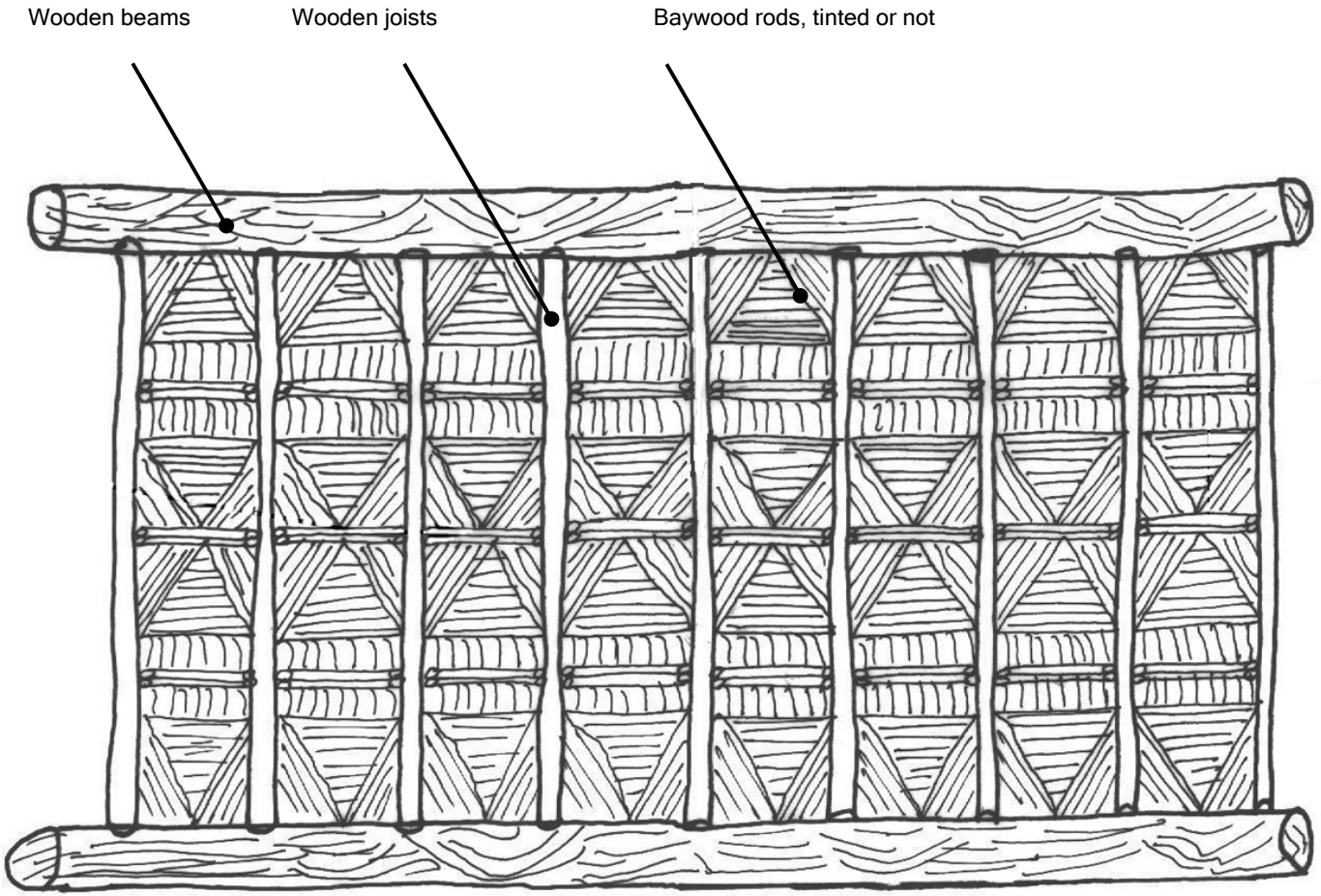
Simple reed ceilings

Reed ceilings are the easiest to implement. The reeds are simply laid over the joists, as tightly as possible. The reeds are not always long enough to cover the totality of the area. In this case, the connections are made above the joists, so as to hide them.
In other cases, the reeds are cut to adapt to the dimension of the distance between the joist's crossings, braided, and then rolled over the joists. They are kept in place by the layer of earth that covers them.

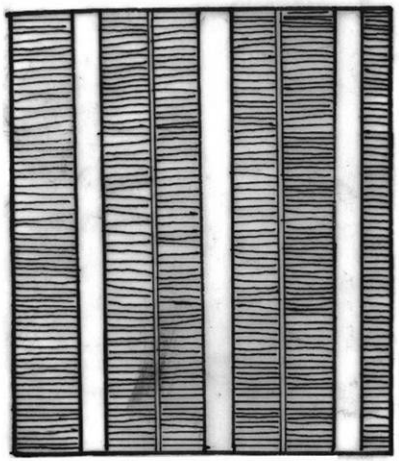
Reconstruction of an earth roof over a reed ceiling

Tataoui ceilings

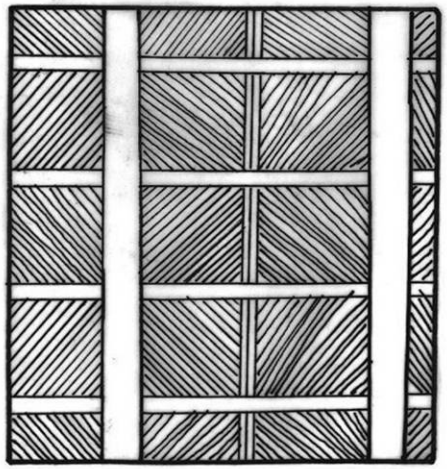
This ceiling is composed of pink baywood rods, tinted or not, laying over a structure of wooden beams and joists. There is a wide variety of geometrical compositions for the construction of these ceilings, that can be more or less complex (see next page). The baywood rods are maintained in place by the weight of the earth layer that covers them, without further connections.



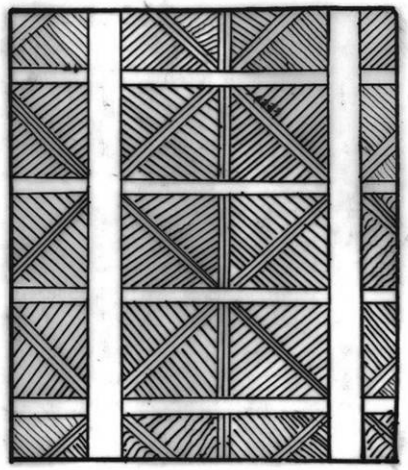
Examples of geometrical compositions



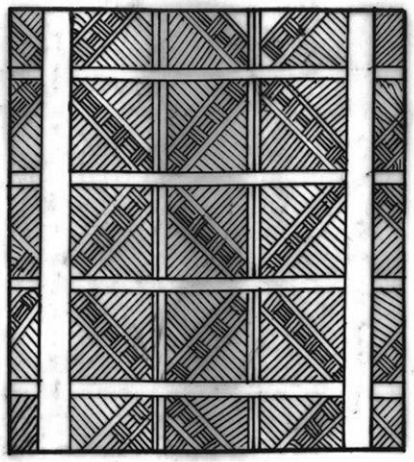
Simple ceilings on a single bed of reeds



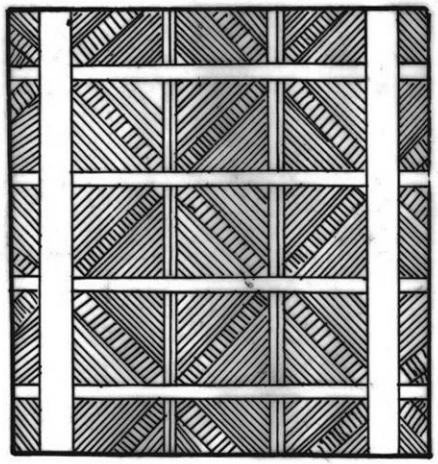
Tataoui ceiling with a double bed of reeds



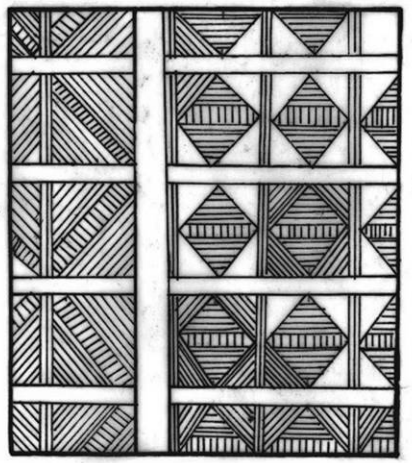
Tataoui ceiling with a triple bed of reeds



Tataoui ceiling with four beds of reeds



Tataoui ceiling with five beds of reeds



Tataoui ceiling with six beds of reeds

6.14. *Dess* coating of terraces

The *dess* is a layer protecting the surface of flat roofs. Implemented in three stages, the *dess* constitutes a protection shell, which allows the drainage of water and protects from high temperatures.

Preparation:
The *dess* is implemented over the layer of earth on the surface of the roof in three stages :

- Creation of a sloped surface using earth that contains large aggregates. In case this type of earth is unavailable, a mixture of river sand and gravel, and earth containing clay can be used. It is also possible to use a mixture of 50% river sand and gravel and 50% hydraulic lime. This layer of no more than 30 cm. maximum thickness on the thickest areas, and of 5 cm. minimum thickness on the finest areas, should be tightened by ramming using a wooden rammer before its hardening.

- Application of a composite coating made of 50% sand and 50% hydraulic lime. This coating is tightened with a wooden rammer before its hardening. It constitutes a resonant monolithic shell.

- Application of a rustic lime wash, that helps to fill-in the small cracks. This lime wash can be tinted using pigments in very small quantities.

6.15. Restoration of terrace roofs

Flat roofs deserve to be carefully maintained, since they ensure the global protection of the building. Flat roofs wear off faster than the rest of the structures. As soon as the roof is left unattended, serious degradations can occur, as water infiltrations surge. Flat roofs should maintain their resistance against many factors of degradation, including :

- Erosion due to rainwater
- Abrasion due to human tramplings
- Strong variation in temperature between day and night

Important elements that ensure the proper operation of a roof are :

- Master beams that are sturdy enough to support the loads efficiently without bending
- A shape that ensures that the water can be properly drained
- The finishing coat made with clayey earth (or with a lime wash) covering the surface of the roof, that serves as a tamper layer, and which helps to fill-in the smaller cracks
- The « hats » that protect the tops of parapet walls.

Maintenance of terrace roofs and parapet walls

Regular maintenance of the roofs and the parapet walls ensures the protection of buildings. After each rain season, it is advised to check the state of the roof, to clean its surface, to clear the roof scuppers, to fill-in the cracks and to correct drainage slopes when the ceiling has undergone deformations, in order to avoid water stagnations. A partial restoration of the eroded spots is advised after each rain season.

Diagram of an accessible terrace roof

6.16. Maintenance of decorations

Interior and exterior decorations should also be considered and conserved. Some errors to avoid are :

- The replacement of degraded decorations with less elaborate decorative elements
- The replacement of sculptured decorations made with bricks, with drawings or paintings

Previous documentation and research

The conservation of decorations is often considered a luxury when compared to other conservation priorities : the repair of a leaking roof, the restoration of the base of a wall, etc.

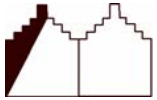
When it is not possible to repair decorative elements threatened by severe degradation at once, it is necessary to make an evaluation of their state and condition in order to repair them at a later date. A series of drawings and photographs can be helpful to keep a record of the style of the decorations, and to reproduce it later based on these records.

How to replace lost decorations?

When a wall has collapsed, or when erosion has erased a decoration, it is necessary to find elements that will allow the production of decorative elements in accordance with the style of the area. There are many possible sources of information :

- The Cerkas is keeping important iconographic archives that can provide references
- Decorations found on the surrounding area can serve as sources of inspiration
- *Mâalems* can also make relevant suggestions and offer advice

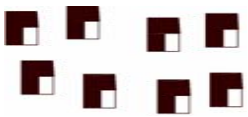
Some standard graphic compositions



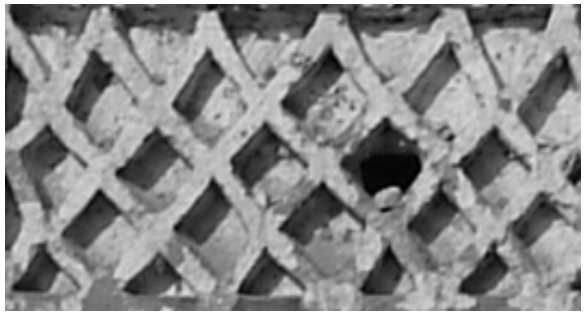


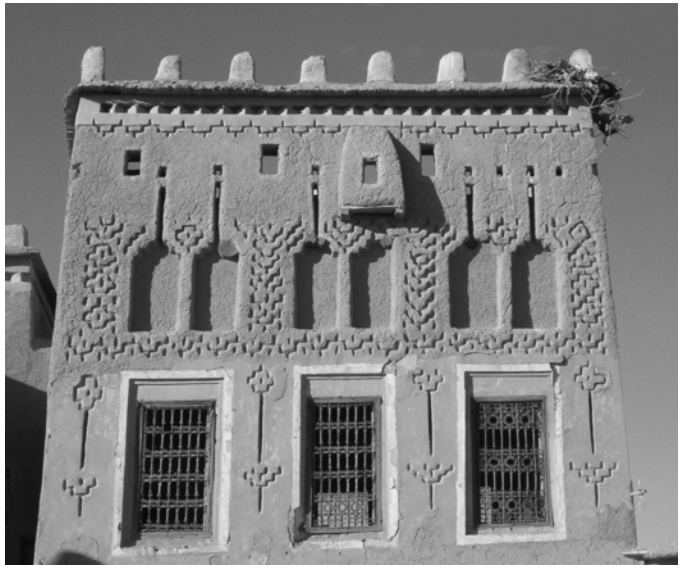


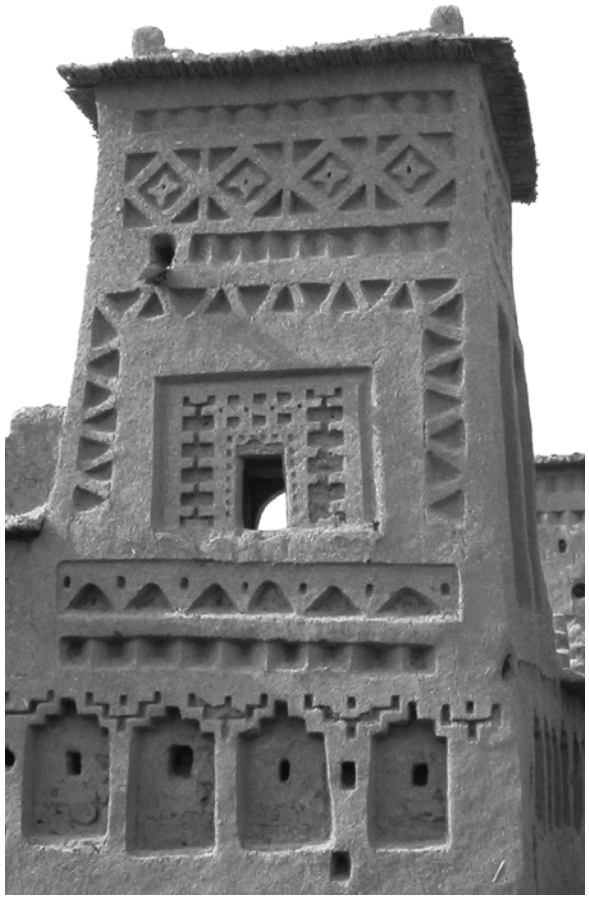


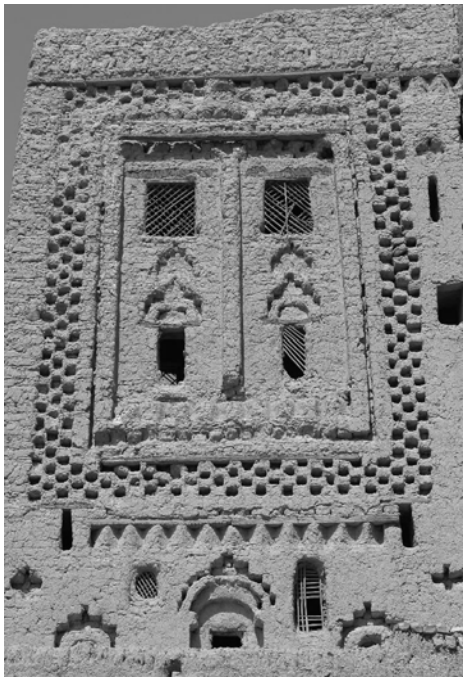
Examples of decorations

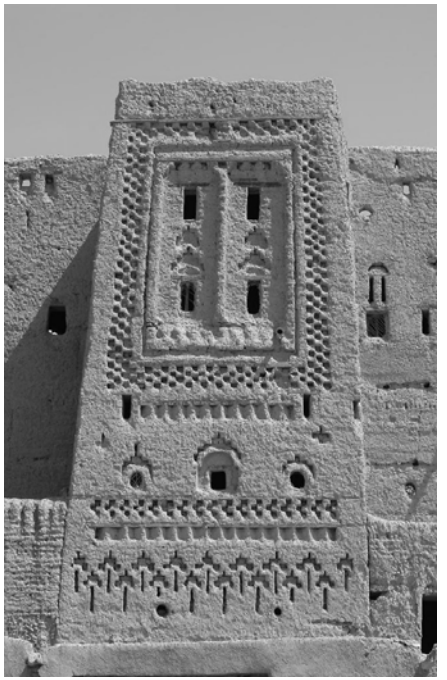






Examples of decorations





7. Modifications

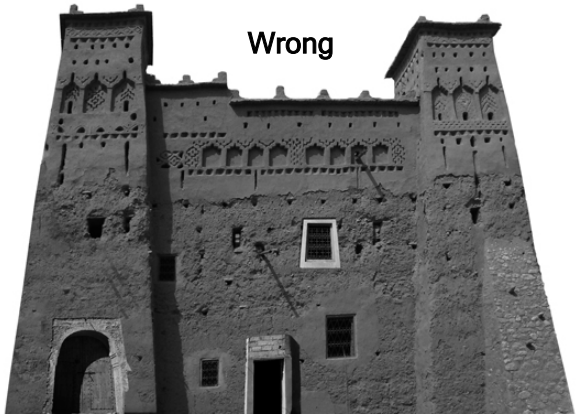
7.1. Creation of new openings

The creation of new openings inexistent in the original structures can, in addition to altering the nature of the building, generate irreversible structural damage. If the creation of a new opening is considered essential, it is advisable to implement it on an interior court or on an unexposed frontage. It is necessary to get inspired from the design, the proportions and the finishing details of the original openings before implementing a new one.

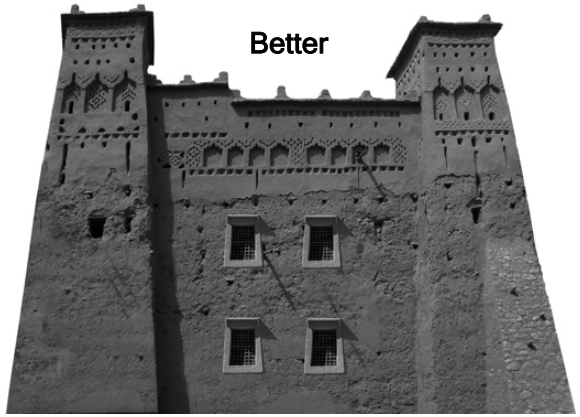
Errors to avoid :

- New openings created on enclosure walls; this alters the defensive nature of these structures and generates new possible entrances
- Enlargement and multiplication of the openings, without any regard for the original opening's disposition
- Creation of very large openings, since they alter the load distribution
- Replacement of traditional doors and windows employing metallic or aluminium frames

Original facade before any intervention



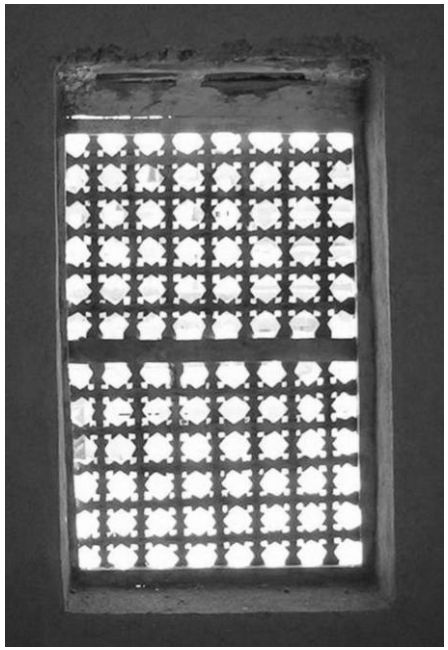
Avoid chaotic openings and the use of foreign, ill-assorted materials.This alters the nature of the architectures and weakens considerably the original structures



Preserve the rythm of the facade, and the original proportions of the existing openings (tall and narrow openings).

Door and window replacement

Copies identical to the original should preferably replace doors and windows that are too damaged to be repaired. It is not allowed to replace ancient joineries with modern joineries, whether they are aluminum, PVC or metal made.



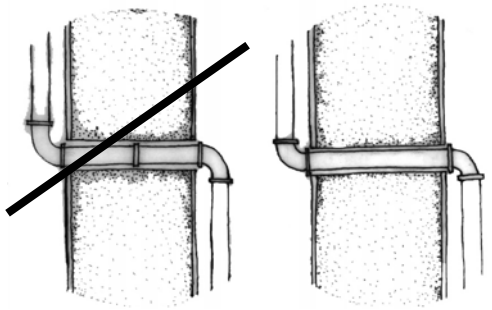
Wooden door and screen wall

Metallic door and window.
This type of replacement solution should be avoided.

7.2. Installation of kitchen, bathrooms, plumbing

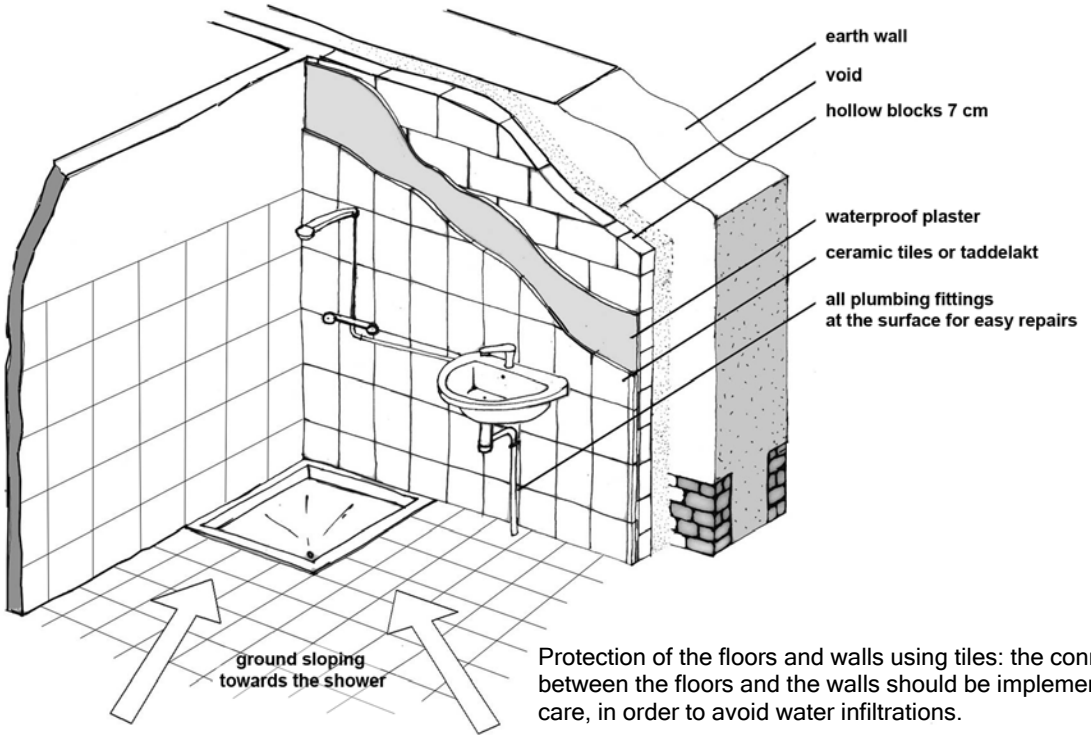
"Damp rooms" are very sensitive areas, since any leakage can generate serious trouble. The drinking water supply system should be accompanied by an efficient wastewater disposal system, in order to avoid water stagnations on the lanes or at the bases of the walls.

Water pipes embedded into the walls can cause considerable damage in the event of a water leak. It is advised to minimize piping through the walls, and to keep water pipes apparent as much as possible.
If the piping is done through the wall, internal connections should be avoided, as seen on the left diagram. The pipes should always be positioned inside a ceramic socket, in order to facilitate their replacement.

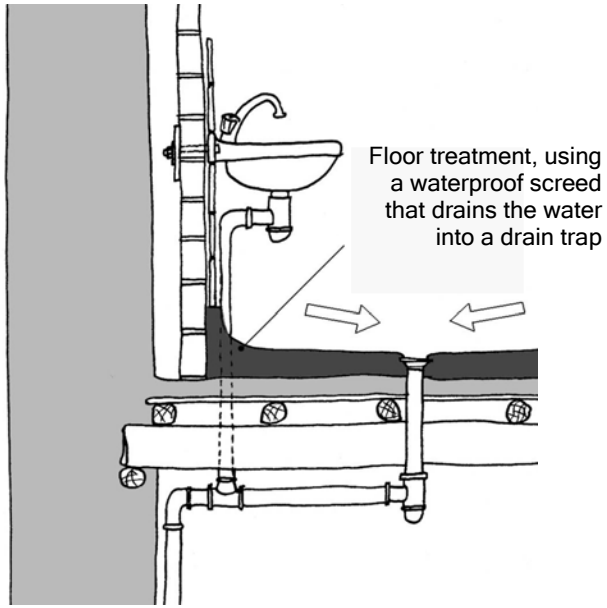


Installation of a « damp room » inside a rammed earth structure:

The diagram below shows some protective options that can help reduce the risk of damping of the structure.



Protection of the floors and walls using tiles: the connections between the floors and the walls should be implemented with care, in order to avoid water infiltrations.



7.3. Electric wiring

In order not to disrupt the authenticity of the villages, it is preferable to hide the electricity network by burying it. Nevertheless, this is a very costly option. The placement of the transformers should be carefully chosen, in order not to disfigure the surrounding landscape and to avoid voltage drops as well. Their implementation should be made in accordance with the building standards, while being well integrated with the local architecture (adobe encasing, additional wood door, external wooden grids, *etc…*).

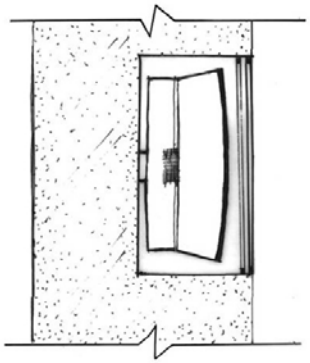
What does the law state?

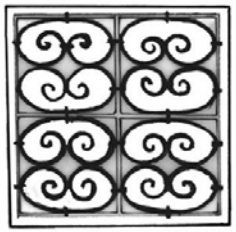
« toute installation de lignes électriques ou de télécommunications extérieures ou apparentes, est soumise à autorisation si elle n'est pas interdite expressément par l'acte administratif prononçant le classement»
(n° 1-80-341 CHAPITRE III - SECTION 1 - Article 23)

Translation: « All installations of power lines or external or apparent telecommunication wires are submitted to an official authorization when they are not expressly forbidden by the administrative act concerning the classification »

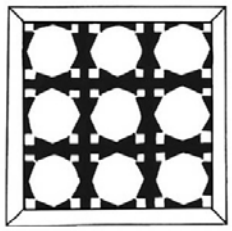
7.3.1. Meter concealing

Electric boxes and meters should be implemented according to the official standards. They can however be encased into the walls, and concealed behind a crafted wooden screen.

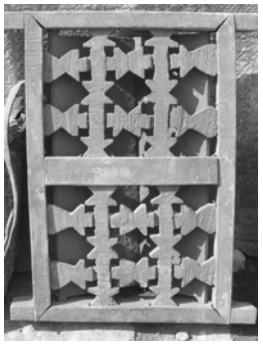




Metal screen

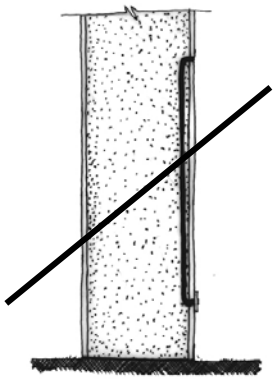


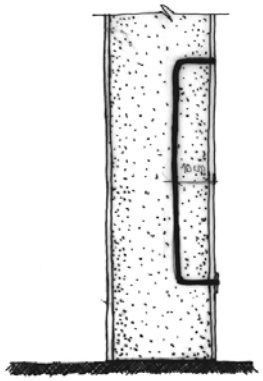
Wooden screen

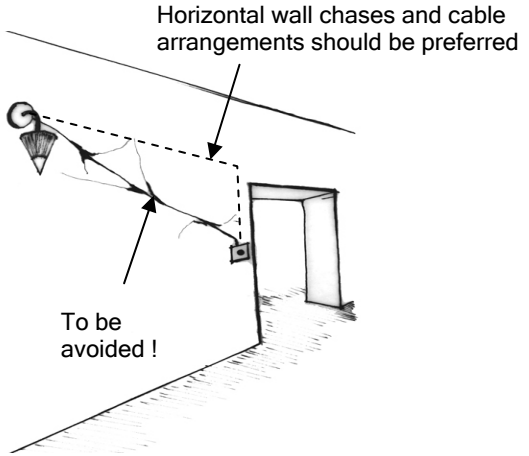


7.3.2. Encasing of shafts

Inside, as well as outside of the houses, electric wires should be properly inserted into shafts that are encased approximately 10 cm. deep into the walls, in order to avoid cracking on the backfilling areas. When interior walls are too thin, and the insertion of shafts could weaken them, it is advised to choose a surface cable distribution, using a wooden casing for example.



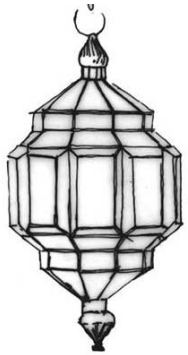




Shaft inserted too close to the surface of the wall

7.3.3. Lamps: shapes and placement

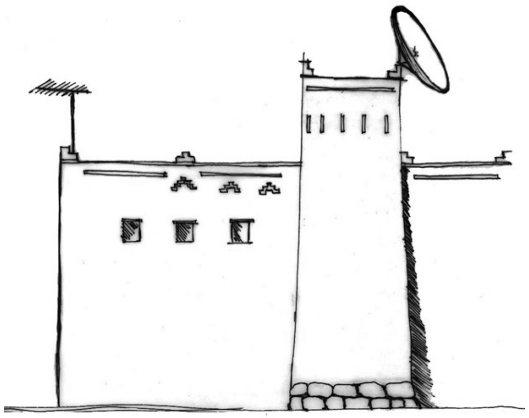
There are many available traditional lantern shapes that can be used for interior electric lighting, either suspended or wall bracketed. Light spots can also be implemented inside niches carved in the walls.

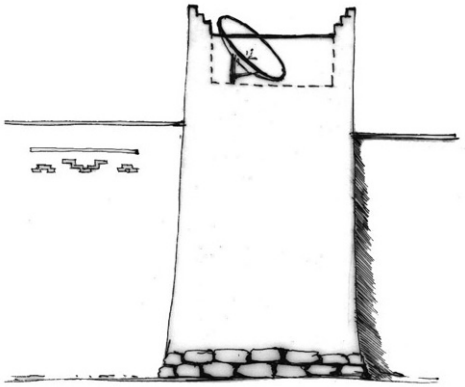


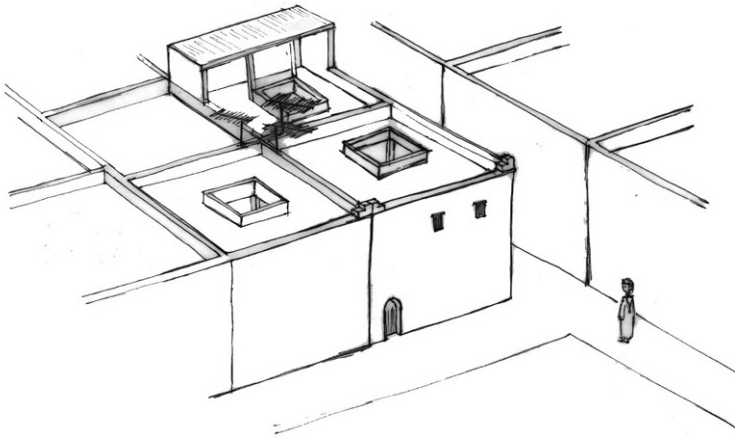
Some examples of traditional lanterns, which can be used for electric lighting

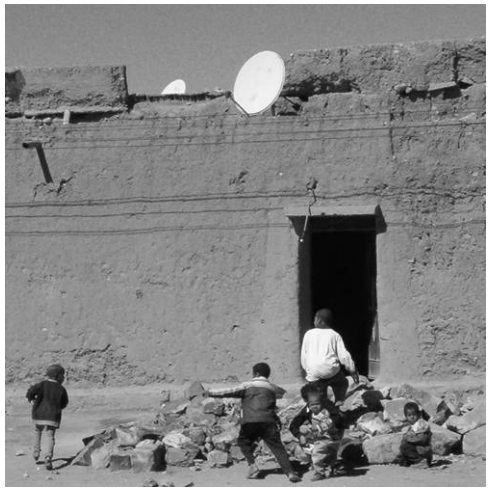
7.3.4. Installation of TV cable and antennas

Television and parabolic antennas in particular are very visible elements in the landscape. These antennas, and the cables that link them to televisions, can be easily hidden on the roofs, behind the parapet walls, instead of being placed directly on the facades.









Antennas visible from the street

Antennas hidden on the terrace roofs, not visible from the street

7.4. Legal dispositions relative to listed heritage (in French)

The following texts refer to the limitations to the possible interventions on listed sites and monuments.

Les effets d'inscription et de classement des monuments et des sites

Dahir n° 1-80-341 du 17 Safar 1401 (25 décembre 1980 portant promulgation de la loi n° 22-80 relative à la conservation des monuments historiques et des sites, des inscriptions, des objets d'art et d'antiquité

TITRE I : DISPOSITIONS GENERALES

Article 1 - Les immeubles, par nature ou par destination, ainsi que les meubles dont la conservation présente un intérêt particulier pour l'art, l'histoire ou la civilisation du Maroc peuvent faire l'objet d'une inscription ou d'un classement.

Article 2 - Sont visés par l'article 1er :

- Au titre des immeubles :
- Les monuments historiques ou naturels;
- Les sites à caractère artistique, historique, légendaire, pittoresque ou intéressant les sciences du passé et les sciences humaines en général;
- Sont assimilées aux monuments historiques et comme telles susceptibles d'être inscrites ou classées, lorsqu'elles présentent un intérêt artistique, historique, légendaire, pittoresque ou intéressant les sciences du passé et les sciences humaines en général, les gravures et peintures rupestres, les pierres écrites et les inscriptions monumentales funéraires ou autres, à quelques époques qu'elles appartiennent, en quelques langues qu'elles soient écrites et quelques soient les lignes ou formes qu'elles représentent.

TITRE II : DE L'INSCRIPTION DES MEUBLES ET IMMEUBLES

CHAPITRE I - PROCEDURE D'INSCRIPTION

Article 3 - L'inscription des meubles et immeubles est prononcée conformément à la réglementation en vigueur.

CHAPITRE II - EFFET DE L'INSCRIPTION

Article 4 - Toute documentation afférente à un meuble ou à un immeuble inscrit peut être diffusée sans que le propriétaire puisse se prévaloir d'aucun droit.

Article 5 - Les propriétaires des immeubles et d'objets mobiliers inscrits sont tenus d'en faciliter l'accès et l'étude aux chercheurs autorisés à cet effet.

Article 6 - L'immeuble ou le meuble inscrit ne peut être dénaturé ou détruit, restauré ou modifié sans qu'avis n'en été donné à l'administration par le ou les propriétaires, six mois avant la date prévue pour le commencement des travaux.

Article 7 - Des subventions peuvent être allouées par l'Etat aux propriétaires d'immeubles ou de meubles inscrits, en vue de la restauration et de la conservation de leurs biens.

L'administration peut entreprendre, à sa charge, en accord avec les propriétaires, tous travaux visant à sauvegarder et à mettre en valeur le bien inscrit.

Article 8 - Les propriétaires visés à l'Art. 5 peuvent, dans le cadre de la réglementation en vigueur, exploiter leurs biens à des fins lucratives dans les conditions fixées par la réglementation en vigueur.

Article 9 - Les immeubles et les meubles inscrits appartenant à des particuliers peuvent être cédés. Toutefois, cette cession est soumise aux conditions prévues par le titre V relatif au droit de préemption de l'Etat.

CHAPITRE III - EFFETS DE CLASSEMENT

SECTION 1 - Immeubles

SOUS-SECTION 1 - effets quant aux immeubles classés

Article 20 - Un immeuble classé ne peut être démoli, même partiellement, sans avoir été préalablement déclassé conformément aux dispositions de l'article 36.

Article 21 - Un immeuble classé ne peut être restauré ou modifié qu'après autorisation administrative.

Article 22 - Aucune construction nouvelle ne peut être entreprise sur un immeuble classé sauf autorisation accordée conformément à la réglementation en vigueur.

La délivrance, par l'autorité communale compétente du permis de construire éventuellement nécessaire, est subordonnée à l'autorisation visée à l'alinéa précédent.

Article 23 - Il ne peut être apporté de modification, quelle qu'elle soit, notamment par lotissement ou morcellement, à l'aspect des lieux compris à l'intérieure du périmètre de classement, qu'après autorisation administrative.

La délivrance de l'autorisation de bâtir, de lotir ou de morceler, par l'autorité communale compétente, est subordonnée à l'autorisation l'alinéa précédent.

Dans les sites et zones grevés de servitudes non aedificandi, les constructions existant antérieurement au classement peuvent seulement faire l'objet de travaux d'entretien, après autorisation. Il ne peut être élevé de nouvelles constructions aux lieux et place de celles qui sont démolies.

En outre, toute installation de lignes électriques ou de télécommunications extérieures ou apparentes, est soumise à autorisation si elle n'est pas interdite expressément par l'acte administratif prononçant le classement.

Article 24 - L'apposition des affiches dites panneaux-réclames, affiches-écrans ou affiches sur portatif spécial et, d'une manière générale, de toutes affiches ou enseignes quels qu'en soient la nature et le caractère, imprimés, peintes ou constituées au moyen de tout autre procédé, est interdite sur les immeubles classés, sauf autorisation.

Article 25 - L'administration peut faire exécuter d'office, aux frais de l'Etat et après en avoir visé le propriétaire, tous travaux qu'elle juge utile à la conservation ou à la sauvegarde de l'immeuble classé.

A cette fin, l'administration peut autoriser l'occupation temporaire du dit immeuble ou des immeubles voisins. L'autorisation d'occupation est notifiée aux propriétaires intéressés. L'occupation ne peut excéder un an.

L'indemnité éventuellement due aux propriétaires est fixée soit par accord amiable, soit, à défaut, par les tribunaux.

Article 26 - Les immeubles classés, domaniaux, habous ou appartenant aux collectivités locales ou aux collectivités régies par le Dahir du 26 rajeb 1337 (27 avril 1919) organisant la tutelle administrative des collectivités ethniques et réglementant la gestion et l'aliénation des biens collectifs, sont inaliénables et imprescriptibles.

Article 27 - Les immeubles classés appartenant à des particuliers peuvent être cédés. Toutefois cette cession est soumise aux conditions prévues par le titre V relatif au droit de préemption de l'Etat.

SOUS-SECTION 2 - Effets quant aux immeubles riverains

Article 28 - Aucune construction nouvelle ne peut être adossée à un immeuble classé.

Les constructions existant avant le classement ne doivent plus, lorsqu'elles font l'objet de travaux autres que de travaux d'entretien, s'appuyer directement contre le dit immeuble. Dans la partie mitoyenne de ce dernier, les propriétaires devront édifier, sur leur propre terrain, un contre mur pour supporter les constructions.

Une indemnité représentative de la servitude d'appui pourra être allouée dans ce cas aux intéressés. Elle sera fixée ainsi qu'il est prévu au dernier alinéa de l'article 25.

Lorsque des travaux sont effectués sur leurs immeubles, les propriétaires riverains sont tenus de prendre toutes mesures nécessaires pour préserver l'immeuble classé de toute dégradation pouvant résulter des travaux.

Ces mesures peuvent, le cas échéant, leur être prescrites par l'administration.

8. Bibliography

Recent references

Boussalh M., **Patrimoine architectural au Maroc : propositions de création d'un équipement culturel intégré dans la kasbah de Taourirt à Ouarzazate**, mémoire de 3ème cycle, Université Senghor, Alexandrie, Egypte, 1999
Feilden M., *Jokiletho J.,* **Guide de gestion des sites du patrimoine culturel mondial**, Iccrom, Rome, Italie, 1996
Fouin J., **La chaux naturelle : décorer, restaurer et construire**, éditions du Rouergue, Rodez, France, 2001
Guillaud H., Zerhouni S., **L'architecture de terre au Maroc**, ACR éditions, Paris, France, 2001
Jlok M., **Patrimoine architectural des vallées et des oasis : état des lieux, évolution et perspectives de développement,**, thèse de 3ème cycle en Anthropologie, INSAP, Rabat, Maroc, 2002
Pickens S., Renaudeau M., Richer X., **Le sud marocain**, ACR éditions, Paris, France, 1998
Rauzier M.P., Tréal C., Ruiz J.M., **Le sud marocain**, Arthaud éditions, Grenoble, France, 1998

References prior to 1990

Adam A., **La maison et le village dans quelques tribus de l'Anti-Atlas**, Collection hespéris, Institut des hautes études marocaines N°XIII, Paris, France, 1951
Beurret C., **Haut-Atlas, paysages, architecture, vie et coutumes, objets populaires traditionnels**, Musée de Grenoble, France, 1980
Gaud M., Sicault G., **L'habitat indigène au Maroc**, Bulletin de l'institut d'hygiène du Maroc, Tome IV, Rabat, Maroc, 1937
Hammoudi A., **L'évolution de l'habitat dans la vallée du Draâ**, Revue de géographie du Maroc N°18, Rabat, Maroc, 1970
Harouchi A., **Habitat et société dans la vallée du Draâ**, Thèse 3ème cycle U.P.A.T., Toulouse, France, 1979
Hensens J., Bauer G., Hamburger B., Dethier J., **Rénovation de l'habitat de la vallée du Draâ**, Rabat, Maroc, 1967
Hensens J., **Habitat rural traditionnel des oasis présahariens**, Bulletin économique et social du Maroc, N°114, Rabat, Maroc, juillet/septembre 1969
Hensens J., **Enquête nationale sur l'habitat rural traditionnel au Maroc**, Bulletin économique et social du Maroc, N°118-119, Rabat, Maroc,1970

Hensens J., **L'avenir de constructions en terre au Maroc**, C.E.R.F., Rabat, Maroc, 1970
Ichter J.P., **Les Ksours de la vallée du Tafilalet**, Revue A + U, Revue africaine d'architecture et d'urbanisme N°11, Rabat, 1972
Houben H., Guillaud H., **Traité de construction en terre**, CRATerre, éditions Parenthèses, Marseille, France, 1989
Ichter, J.P., Sass, H., **Les Ksour du Tafilalt**, revue africaine d'architecture et d'urbanisme n°5, Rabat, 1967
Ichter, J.P., Duru, H., Decoville, D., « **Kasbas » des vallées présahariennes**, revue africaine d'architecture et d'urbanisme n°5, Rabat, 1967
Ichter, J.P., **Maison du Rif**, revue africaine d'architecture et d'urbanisme n°5, Rabat, 1967
Jacques-Meunier D., **Greniers collectifs.** Hespéris, Archives Berbères et Bulletin de l'Institut des Hautes-Etudes Marocaines, tome XXXVI, 1° et 2° trim., Paris, 1949
Jacques-Meunier D., **Greniers citadelles du Maroc.** Institut des Hautes Etudes Marocaines, Tome LII, Paris, 1951
Jacques-Meunier D., **Sites et forteresses de l'Atlas, monuments montagnards du Maroc.** Paris, 1951
Jacques-Meunier D., **Architectures et habitats du Dadès.** Librairie Klincksieck, Paris, 1962
KASBA 64., **The kasbas of southern Morocco**, Faber and Faber, London, Royaume-Uni, 1969
Ministère et l'intérieur., Direction de l'Urbanisme et de l'habitat, C.E.R.F., Rabat, plusieurs publications relatives à l'architecture de terre entre 1967 et 1972 :

- **Rénovation de l'habitat de la vallée du Draâ**, 1967
- **Rénovation de l'habitat traditionnel des vallées présahariennes**, 1968
- **Rénovation de l'habitat de la vallée du Draâ dans le cadre du programme national de développement rural 1968-1972**, 1967
- **Habitat rural traditionnel du Draâ, tendances d'évolution**, 1969
- **Rénovation de l'habitat traditionnel des vallées présahariennes, études opérationnelles - Méthodes**, 1969
- **Rénovation de l'habitat traditionnel du Draâ – Qsar de Tamezmonte**, 1969
- **L'habitat rural au Maroc, enquête nationale sur l'habitat traditionnel, habitation, résultats partiels**. 1972

Montagne R., **Une tribu berbère du Sud Marocain : Massat**, Hespéris, archives berbères et Bulletin de l'institut des Hautes Etudes Marocaines, Tome IV, 4ème trimestre, Paris, 1924
Montagne R., **Un magasin collectif de l'Anti-Atlas : l'Agadar des Ikounka**, Hespéris, archives berbères et Bulletin de l'institut des Hautes Etudes Marocaines, Tome IX, 2ème et 3ème trimestre, Paris, 1929
Montagne R., **Villages et Kasbahs berbères**, Allan, Paris, 1930
Paris Dr . A., **Documents d'architecture berbère, Sud de Marrakech**, Larosse, Paris, 1925